POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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Something of Current Interest

AS A FEATURE OF particular current interest this month we present this picture of an engineer examining a piece of not very well made copper tubing which evidently had been wound around the cylinder he is holding. But, you may ask, what is there of unusual interest in that? Hundreds of engineers wind copper wire and copper tubing into coils every day all over the country—why get so excited about this particular example?

We admit all this and agree that as a specimen of copper tubing this piece has a lot of shortcomings. The interest, however, lies not in the tubing itself but in the way it was made. For this is a picture of W. G. Roman of the Westinghouse high voltage laboratories, and the piece of copper tubing which he is so interested in was formed out of a flat copper strip in a few millionths of a second by a momentary high current, high frequency surge.

This was all. There was no other equipment involved—no forms, no mandrels, no mechanical devices of any kind, and furthermore, no heat, that is, no unusual heat. Just the current passing through the flat strip curled it instantly into a tube. The current, however, was rather unusual—it was over 200,000 amperes!

In the experiment, a one inch wide by 1/32 inch thick soft copper strip was clamped tightly around a 4½ inch diameter coil, 12 in. long consisting of 24 turns of No. 9 cable. A 50,000 amp. surge at 100,000 v. was then sent through this coil which induced a current of 211,000 amp. in this one turn short circuited secondary. The resulting magnetic fields instantly curled the flat copper band into a copper tube as shown here.

Two hundred and eleven thousand amperes! That, in the vernacular, would be considered a lot of "juice". And yet it may be somewhat of a surprise to many reading this that a current of this magnitude is relatively small compared to the current densities which prevail at the brushes of even a small direct current generator. For, at the sliding contact formed by the brushes on the commutator or on the collector rings of an a.c. motor, current densities of a million amperes per square inch are common. Indeed, in some cases the current densities reach several million per square inch!

All this leads to the article on Electrical Sliding Contacts which appears in this issue. Research workers are responsible for these astonishing utterances. They have become dissatisfied with the little information known about brushes and brush contacts and the small progress made in forty years of cut and try methods which have heretofore been used in solving brush problems. Recent investigations at the Westinghouse laboratories have shown that the actual areas of contact in a graphite brush riding on a graphite slip ring are extremely small resulting in local current densities of enormous magnitudes. In the article presented on page 528 R. M. Baker discusses this question in a most interesting manner.

While his discussion is largely of a theoretical nature it is one which ultimately will point the way to better brush design. It may tell us why even under the best mechanical conditions some brushes perform definitely better than others. When we understand the fundamental processes of current collection and commutation, we will know how to design brushes to perform better than the best brushes now available. are presented in the article on page 528.

In these days of rehabilitation of power producing equipment it is desirable to get accurate information on all types of prime movers. Among other things the Diesel engine should be looked into, for the Diesel engine in many instances is a highly efficient prime mover. Looking into the Diesel engine is not always an easy matter for the manufacturers have been extremely reluctant to put windows into their engines so one can look into them. Recently, however, the National Advisory Committee for Aeronautics, put a window in a Diesel engine and then put a high speed motion picture camera in front of it so as to take movies of whatever went on inside. While these movies are somewhat less appealing than those of Claudette Colbert or Jean Harlow, at the same time it must be admitted that they are distinctly novel, and those interested in internal combustion engines should find them of unusual interest. The results of this study are presented in the article on page 525.

WITH THE EDITORS

An End to Unemployment

IN A CIVILIZATION which is capable of constructing a Boulder Dam, of transmitting the human voice instantly across 11,500 miles of the earth's surface, of virtually eliminating such once dread diseases as typhoid and malaria, it seems strange that so seemingly simple a problem as that presented by unemployment should remain unsolved. For compared to some of the problems in biology and physics, the problem of unemployment is, theoretically, not difficult. We have all the elements required for its solution—a nation, or world, with abundant natural resources, a technique for multiplying and enriching these resources to almost any extent desirable, a world of human beings to work and to utilize and consume these resources and finally a philosophy and desire on the part of the majority to solve the problem, peacefully and quickly. Certainly no one can doubt but that there is sufficient intelligence in the world to solve the problem. Then why don't we do it? Why don't we end unemployment?

Ralph Flanders asks this question and presented his ideas regarding the subject in a recent address before the Metropolitan Section of the American Society of Mechanical Engineers, and our purpose in repeating the question here is not to discuss it so much as to direct attention to Mr. Flanders' address which is well worth reading.

Without going into detail, Mr. Flanders proposes first the setting up of unemployment insurance to cover a limited period of unemployment, such as that required in finding a new job under ordinary circumstances. Such a system must be country-wide.

Next, to cover periods of more prolonged unemployment in times of economic readjustment such as those existing at present, he recognizes the need of highly organized movements, such as the CCC, the CWA and the FERA to advance a number of socially desirable projects. Successful functioning of such movements requires a permanently and efficiently organized public works administration—"a careful study and laying out in advance of a multitude of socially desirable projects the completion of which shall slowly transform the physical aspects of the country from the Atlantic to the Pacific and from the Gulf to Canada into forms capable of ministering to the highest enjoyment of its citizens." This work would tie in with normal government projects, local, state and national, and such a public works administration should continue from administration to administration, irrespective of political changes.

Thus, we would have, first, limited monetary relief, second, unlimited work on socially desirable tasks at subsistence wages and third, a normally increasing volume of public construction under standard conditions, concentrated in periods of greatest unemployment.

Finally, Mr. Flanders points out, these three lines of defense should be coördinated by a national system of employment offices, to which everyone wishing to draw on these unemployment reserves must go. No one will be considered unemployed who does not register.

These, broadly, are Mr. Flanders' proposals, and while the success of such a plan is naturally dependent upon an adequate financing program and sound management free from tinkering for political advantage, it is a proposal well worthy of our serious consideration, not only because of its noble purpose but because our industrial civilization should be physically capable of providing a job for every man at any time, by which he may earn subsistence when private employment fails. And as Mr. Flanders points out, unless our civilization can furnish such employment, and create or rekindle the spirit of pride in self-supporting sufficiency of all able-bodied workers, with proper incentive to self-help and independence, it is doomed to a deserved decay.

Give the Boys a Hand

AS THIS ISSUE of Power Plant Engineering comes to its readers the gates of A Century of Progress Exposition will be closed for the last time. With this noteworthy undertaking passing into history a contemplation of what it has accomplished will reveal the opening of innumerable avenues through which the human race may and will advance its living conditions, industry and culture.

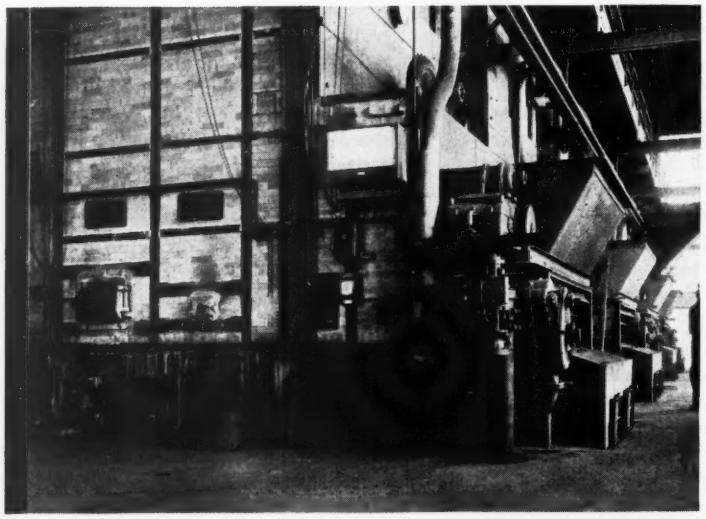
To the engineer the theme of the Exposition, the history of the development of the discoveries of science into application to the service of mankind, has made a strong appeal and many a visitor to the Fair has gone away with a much clearer idea as to "how the wheels go round" in the home, in industrial processes and even in his own human body. Those who took full advantage of the Exposition have had a liberal university education presented to them in the most pleasing and fascinating manner imaginable and will apply many ideas they have learned to their daily living and tasks.

Universities and technical schools may advantageously adopt methods used here for illustrating and demonstrating scientific principles. Electricity at work in the home and shop held the interest of young and old alike. Transportation, industrial processes, agriculture, foods, horticulture, social science, each had its appeal to people of varied interests.

Carried out during a major depression to a successful finale, both as a financial enterprise and an educational and entertainment undertaking, the management of the Exposition is to be highly congratulated on the beneficial results which have been attained in disseminating new and useful ideas to millions of people from all sections of the world.

Power Plant Services *for t*

Century Distilling Co. of Peoria, Ill., Takes Advantage of Modern Equipment to Give Economy and Flexibility Demanded of Power Services by Today's Distilleries.



By F. C. Gedge,
Master Mechanic,
Century Distilling Co.

WITH THE RESULT of the national referendum on the 18th amendment a foregone conclusion, the Allied Mills, Inc., manufacturers of stock feeds and soya bean products, even as early as the spring of 1933, decided on a program of reconstruction in the plant known in pre-prohibition days as the Atlas Distillery. This property is located in the extreme southwestern section of Peoria, Illinois, with excellent shipping facilities on two major railroads.

Peoria, a city of 105,000 people, located on the Illinois River one hundred sixty miles southwest of Chicago, has always been known as one of the greater distillery and brewery centers of the West. It lies in the center of the grain belt, provides an immediate supply of a fair grade of cheap coal, and is an excellent labor market. Still more important, from the distiller's viewpoint, it provides an almost unlimited supply of cold and very pure water, available in a gravel sub-strata lying at a depth of from 60 to 90 ft. below the river level. The flow of this subterranean stream is southeasterly from the hills on the west shore of the river, hence there is no contamination from river water.

The old Atlas plant consisted of a group of brick and frame buildings covering approximately 7 a. of land. All the old equipment had previously been removed, except that in the grain elevator and mill proper where the grain is ground into meal as the first step in the process of distillation. Although a majority of the buildings were in a deplorable condition, it was decided to repair rather than replace them with the exception of the old boiler house and engine room, which were completely demolished, the reason for this decision being that it was essential to start operation at the earliest possible date after repeal had become an accomplished fact. Immediately adjacent to the distillery is a soya bean plant operated by the parent company, Allied Mills. This plant operated an obsolete boiler plant and purchased power from the local public utility company.

Active work on the project was begun in July, 1933, and the plant went into operation on January 5, 1934, with a grind of 5600 bu. of grain per 24 hr., or a production of approximately 190,000 bbl. of liquor per yr. Shortly before operations were begun, the company was organized, and is at present operating as the Century Distilling Co. The general design of the plant is such that federal license is had to operate either under an industrial alcohol permit or as a whiskey distillery, whichever market conditions dictate.

Process

In the modern distilling process, the grain (usually corn and rye), is ground to a coarse meal, cooked into a mash with live steam by direct contact, then cooled in a water-jacketed coil, known as a mash cooler, to about 65 deg. F. The cooled mash is then collected in a 70,000 gal. closed top fermenter tank, where yeast is added. Fermentation then takes place, requiring approximately 72 hr. The fermented product, called "beer," then passes through the first of a series of continuous stills, using exhaust or live steam at 15 lb. ga. in direct contact, to distill out the alcoholic vapors. The vapors are condensed in surface type condensers

or the Modern Distillery

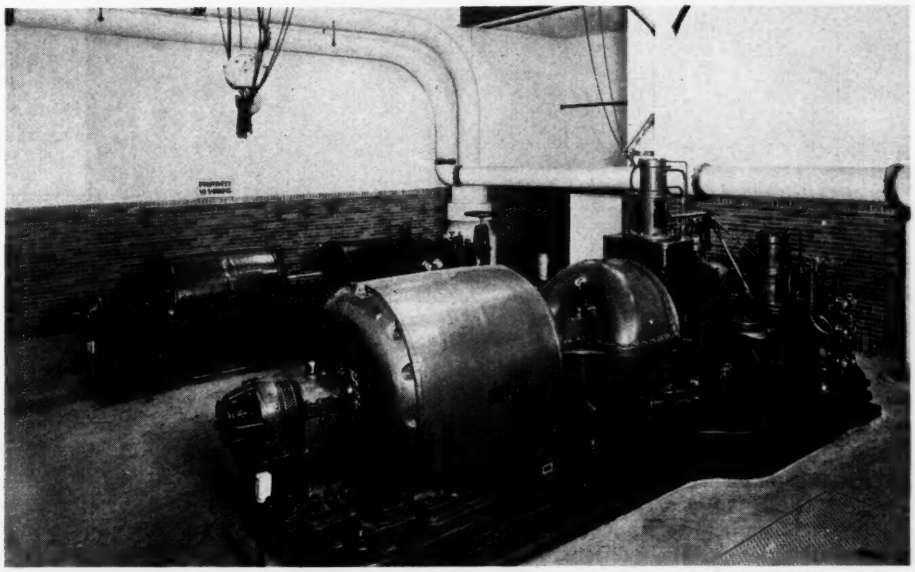


Fig. 1. General view of Turbine Generating Units

by cooling water maintained at a temperature not to exceed 65° F.

In the modern still the low wines, aldehydes, fusel oil and spirits (high proof alcohol at 192 proof, or 96 per cent alcohol by volume) are automatically separated one from the other, and carried to separate storage tanks. The liquid and grain solids remaining, called "slop," are pumped from the still, screened and filtered. The liquids through the screens are concentrated in triple effect evaporators using exhaust or live steam at 5 lb. ga., by indirect heating. This concentrate is then added to the grain passing over the screens and the entire mass is dried to approximately 10 per cent moisture content by passing through a series of steam heated, rotary driers using live steam at 120 lb. ga. The dried grains constitute a protein stock feed of the highest grade.

From this brief description it may be seen that there is no loss in the modern distillery of any of the original grain taken into the process. The economic trend prohibits the loss of any of the "thin slops" or spent grains, which product in the old days often caused unsightly and unpleasant conditions to exist in the nearby sewers and streams.

The preliminary analysis of distillery steam and power requirements indicated the advisability of taking over the steam and electrical load of the soya bean plant, since by so doing a better power balance was made possible for the distillery, as well at a considerable saving effected in power costs to the soya bean plant. The flow sheet, Fig. 4, is a graphic presentation of this analysis.

Since the operation of both the distillery and soya bean plant is continuous during the six 24 hr. working week days, load fluctuations are negligible. Therefore, the generating equipment was calculated for operation at full rated capacity. On Sunday both plants are idle, and with this in mind one of the two Allis-Chalmers generating units is driven by an automatic, bleeder type, condensing turbine. The second unit, which operates during the week days only, is driven by a non-condensing turbine. This arrangement permits the use of both machines during the operating period as non-condensing units, and the use of one machine during idle periods, operating condensing at a very economical water rate, taking care of idle period requirements for lights, water and boiler auxiliaries.

Factors deciding the relative sizes of the two units are the steam requirements of the Still House, namely 21,000 lb. per hr. at 15 lb. ga. The No. 1 unit supplying this steam is therefore a 625 kw. non-condensing machine exhausting at 15 lb. ga. directly through the 15 lb. system to the Still House. In order to establish the electrical balance load, the No. 2 unit is a 750 kw. bleeder type, condensing machine. This unit is so designed that its extraction stage passes 25,000 lb. of steam per hr. at full load, at a pressure of 5 lb. ga. This volume of steam meets the normal requirements for the evaporator and yeast room process, with a small surplus returning to the feed water heater in the boiler room. Thus the two turbines normally function as reducing valves to meet process steam requirements. Since there is a demand for all the steam leaving the turbines, the actual cost of fuel for power generation is very low; namely, the difference between heat input to and heat output from the turbines. As a result, the cost of power, including capital charges, is approximately one-half of Central Station rates.

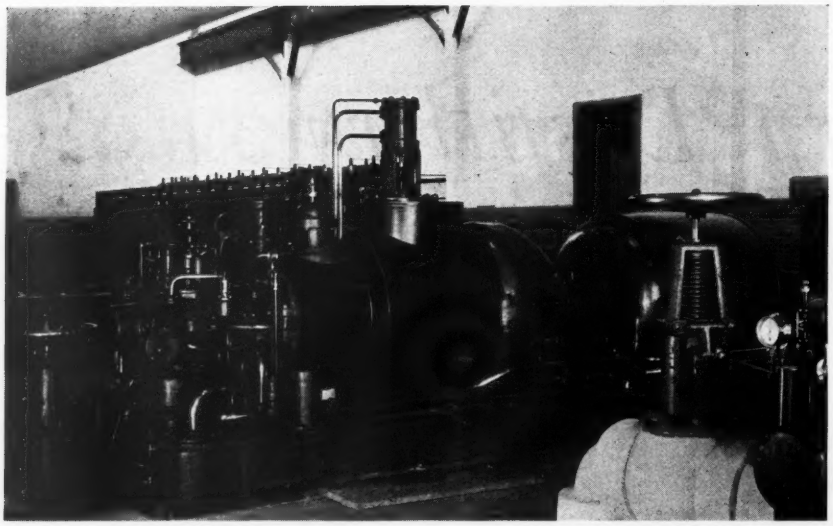


Fig. 2. A steam driven air compressor, partially visible at the left hand edge of the picture, exhausts to the 5 lb. system.

The General Electric switchboard, consisting of two individual generator panels, one exciter panel, one small wing panel for synchronizing, and thirteen departmental distribution panels, is located on the turbine room floor and is under the supervision of the operating engineer. Mounted on each generator panel are an indicating ammeter and watt meter, also a d. c. ammeter for the exciter; time over-current relays and instantaneous under-voltage relay; exciter and generator field rheostats, necessary switches and a registering watt hour meter. On the exciter panel is a power factor indicator, voltage regulator and selector switch, and a recording watthour meter for recording the total plant load. The wing panel carries a synchroscope; three indicating volt meters, for line voltage, voltage of the on-coming machine, and exciter voltage; and a frequency indicator.

Each of ten department panels has mounted on it an indicating ammeter, time over-current relays, hand operated oil switch and a registering watthour meter. A panel is also provided for an emergency power line from the public utility company. Mounted on it are two switches, one connected to the emergency line and the other to the station bus. These switches are interlocked to eliminate the danger of tying the two systems together. The emergency line is connected to the boiler room and plant lighting panels only. Completing the switchboard is a panel carrying switches controlling the lighting circuits in each separate department.

All leads from the department panels are carried in underground conduits to their respective department boards. These boards are all safety, dead front type distribution cabinets, having separate insulated compartments for each circuit, so arranged that live parts are inaccessible when the cover of any unit is opened. It is evident that this separation of each department and each unit makes it possible in event of trouble to isolate any one without affecting the operation of the balance of the plant. As an additional safety measure, explosion proof lighting fixtures and switches are installed in all buildings where there is any possibility of the presence of alcohol fumes or vapors.

Compressed air for process purposes is furnished by a Worthington steam driven air compressor, capacity 500 cu. ft. per min., also located in the turbine room and operated by an automatic pressure control valve, which maintains the pressure between 80 and 90 lb. ga. The exhaust from the compressor is piped through an oil separator to the 5 lb. exhaust steam system and is used in the process.

As mentioned in the introduction to this article, one of the primary requisites of a distillery is pure, cold water. This is supplied by three deep wells, equipped with vertical motor driven, centrifugal, submerged pumps, of a capacity of 1350 g.p.m., pumping

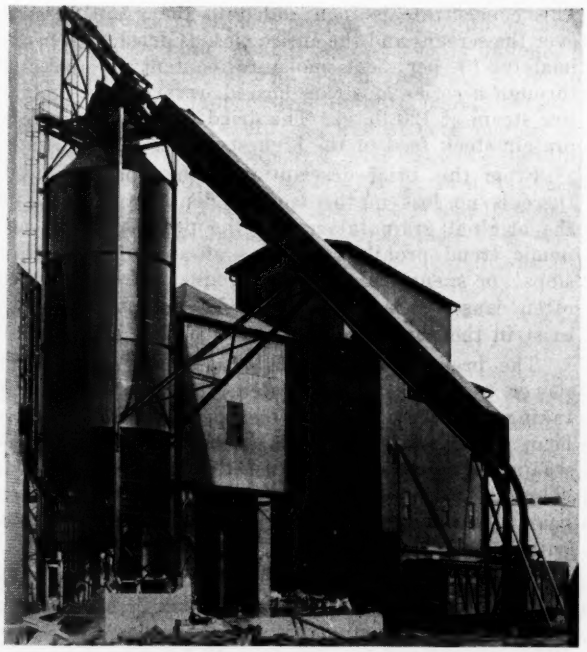


Fig. 3. Coal is carried from the track hopper over the tracks to the bunker by a skip hoist

water at a uniform temperature of 51 deg. F., and discharging into a 40,000 gal. service tank elevated 80 ft. above ground. The pumps are controlled by means of automatic pressure switches located in the turbine room, thus placing the water supply directly under the constant supervision of the engineer. This grouping of all electrical, air and water control equipment results in extremely economical operation, since but one engineer per shift is required in the turbine room.

Flexibility in operation of the various steam systems is obtained by shifting a suitable part of the electrical load during part load operation from one machine to the other, to meet changes in steam requirements. Deficiencies in process steam that cannot be taken care of by this means are then compensated for by the admission of live steam through pressure regulators at various points in the systems. The schematic diagram Fig. 5 indicates the more essential details of the steam systems.

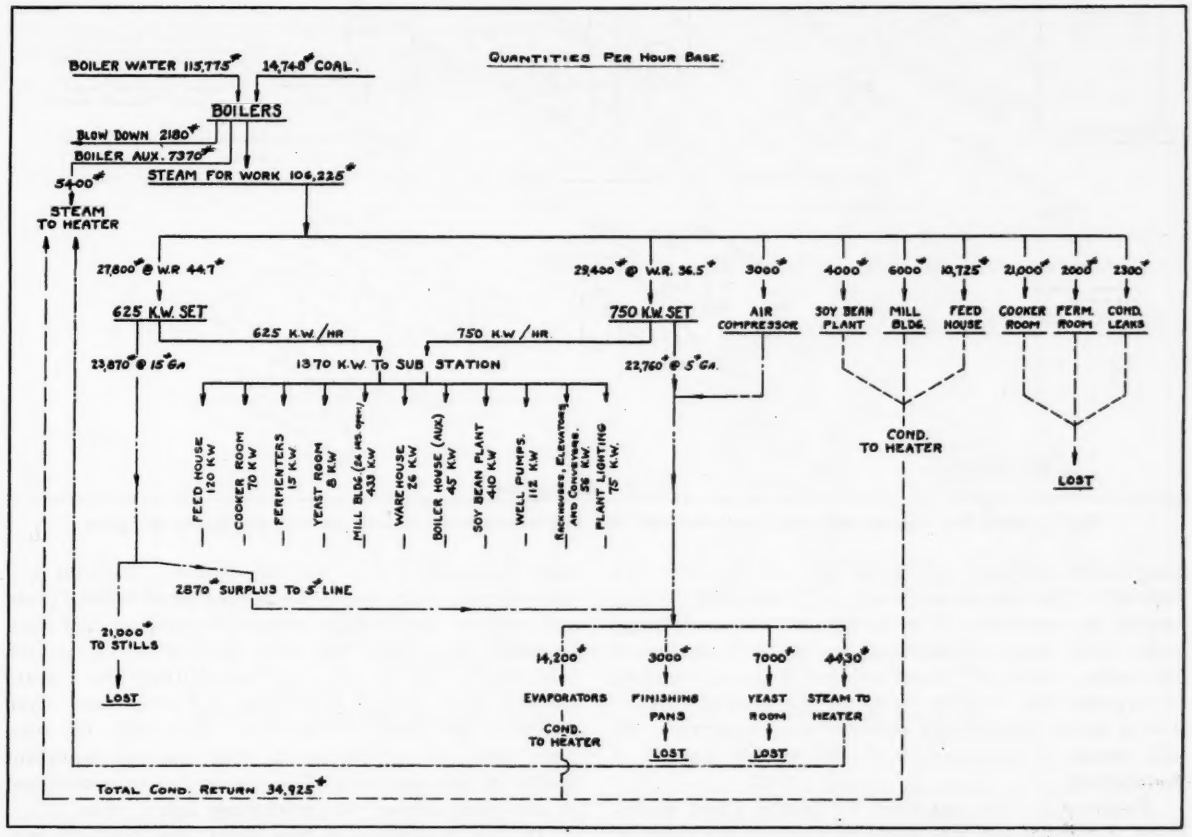


Fig. 4. Distribution diagram of steam and power throughout the distillery and adjacent soya bean plant

The Boiler Plant

The boiler plant consists of four Babcock & Wilcox 500 b.hp. single pass, Stirling type, water tube boilers of welded drum construction for 199 lb. pressure, with convection type superheaters hung between the upper sections of the first bank of tubes. Checker type baffles are set between the third row of tubes from the combustion chamber, effecting a cross flow of gases over the entire heating surface, and results in an extremely low draft loss through the boiler, namely 0.38 in. water gage at 200 per cent rating.

Each boiler is equipped with Bigelow-Liptak flat suspended combustion and rear arches, and with unit-supported, air-cooled sidewalls, bridge and front curtain walls. Access and inspection door openings are fitted with framed radial tile to eliminate use of sprung brick work. Air from walls is collected by a small fan and used overfire, a row of nozzles being provided through the main combustion arch. Each boiler is fired by a Laclede forced draft, chain grate stoker of 108 sq. ft. active grate surface. Air for the forced draft is furnished by motor driven individual fans at a duct pressure of 2 in. water gage.

Waste gases pass through a common breeching to a radial brick stack 9 ft. 6 in. in diam. by 200 ft. high. The stack is designed to permit operation of the entire battery at 100 per cent rating with natural draft, as a precaution against failure of any unit of the forced draft system. Normal plant load requires the operation of three boilers at 200 per cent rating, delivering steam at 155 lb. ga. and 70 deg. F. superheat.

As shown on the flow sheet Fig. 4, approximately 34 per cent of the steam is returned as condensate to the deaerating, closed type feedwater heater and thence to a 5000 gal. feedwater storage tank directly below the heater. The make-up water, constituting 66 per cent of the total feed, is taken from the 40,000-gal. well water storage tank, and softened in the two-

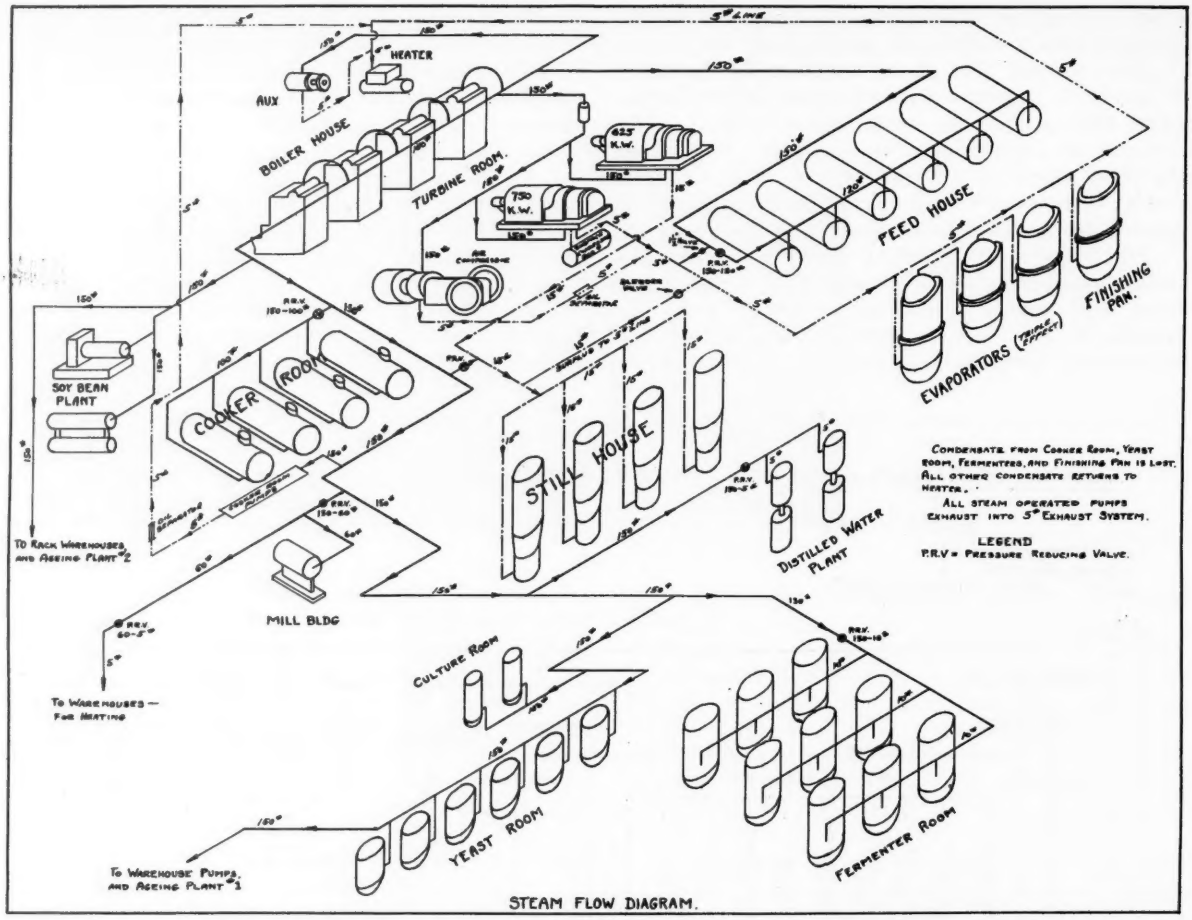


Fig. 5. Steam flow diagram indicating where the high, low and intermediate pressures are used throughout the plant

unit zeolite softener of 12,000 gal. per hr. per unit capacity. The temperature of the feedwater is controlled by operation of a turbine driven centrifugal boiler feed pump, exhausting into the 5 lb. system at the heater, when additional exhaust steam is required to augment the surplus steam in the system. Otherwise a motor driven feed pump is kept in service. By this means a temperature of 190 to 220 deg. F. is maintained.

Previous to the purchase of power plant equipment, a comparison was made of the relative value of three methods of fuel burning; namely, the unit system of pulverized coal, the forced draft chain grate and natural draft chain grate. In making this comparison it developed that with the low priced Springfield district coal as fuel, the forced draft chain grate showed much better return on the investment than either of the other two systems. Naturally, the relatively small size of the steam plant was an important factor in this analysis. The second factor considered in this comparison was producing labor costs.

In the designing of the plant, the thought was

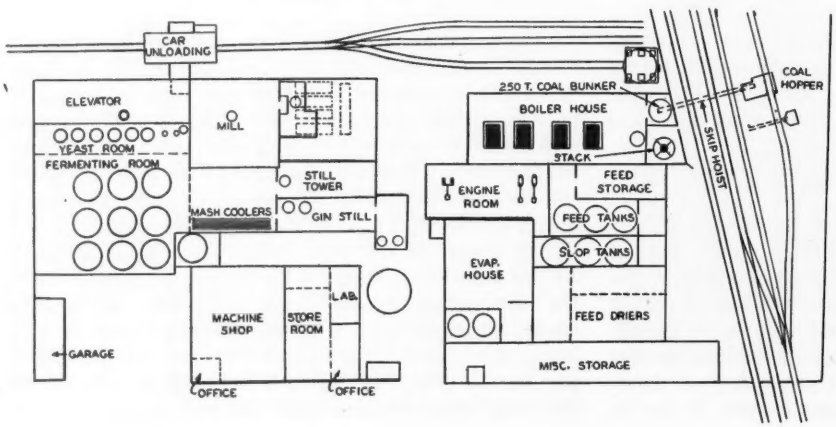


Fig. 6. Plan of the distillery showing the location of the power plant.

kept in mind that but two men per shift would constitute the operating force. To accomplish this end, only such equipment was considered as would require the absolute minimum of labor in operation and maintenance. The important pieces of equipment that made the two-man plant successful warrant a brief description.

For the first essential, fuel handling, a fully automatic skip hoist is employed. The coal, already crushed to 1¼ in., is delivered in self-emptying hopper bottom cars to a 20 t. track hopper. A 2 t. Beaumont skip bucket, motor driven through automatic start, stop and time delay controls, is filled by a mechanical loader under the track hopper, and discharges into the top of a 280 t. cylindrical coal storage tank located at one end of the firing aisle. A 2 t. track larry car, with automatic loading, starting and stopping devices, transfers the coal from the bottom of the storage tank to the stoker hoppers. All tendency toward segregation of the coal is eliminated by the action of the larry, which is so arranged that the coal is discharged by manual control while the car is in motion. The coal is then tempered by admission of exhaust steam through suitable piping just above the stoker feed gate.

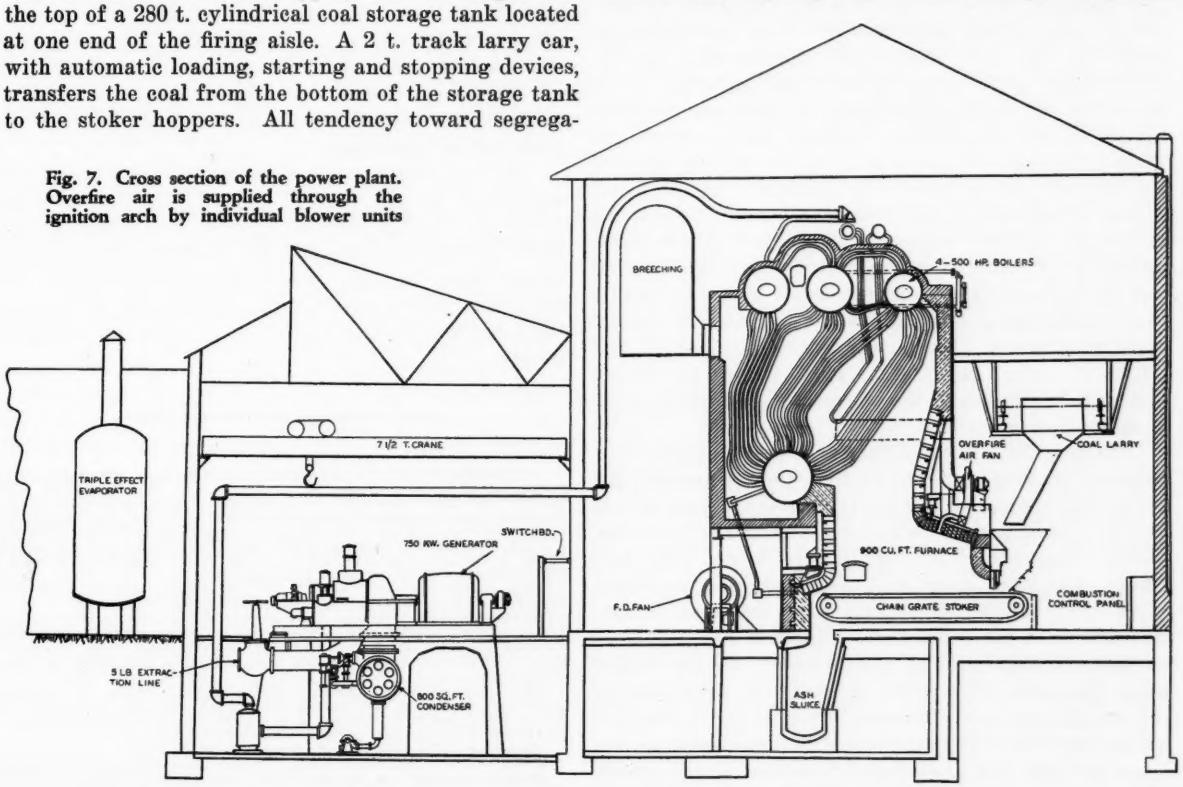


Fig. 7. Cross section of the power plant. Overfire air is supplied through the ignition arch by individual blower units

The next important factor, proper combustion, was provided for by the installation of a Smoot automatic combustion control. The equipment selected is of the quantity type; i.e., coal feed, air flow and furnace draft are proportioned accurately, one to the other, for each load condition, regardless of variables in stoker speed, fan pressures, fuel bed resistance and stack conditions. Each boiler has its own stoker control, fan control and furnace draft control. The stoker speed and air volume controls are actuated by a plant master control. The furnace draft control is weight loaded to maintain a constant furnace pressure under all load conditions. The master control is actuated by variations in plant steam pressure. The range of the control may be varied by adjustments at the master; thus, with a load not to exceed a 50 per cent fluctuation, it is economical to set the master with a permissible pressure variation of less than 10 lb. This covers boiler operation over a range of 100 to 200 per cent of rating. The control unit functions as follows: a change in steam pressure causes an inverse change in air loading pressures at the master control which are dispatched to various regulators which control combustion at the boilers.

The master air loading pressure to the stoker speed regulator is transmitted to the top of a diaphragm chamber, and is counterbalanced on the other side of the diaphragm by a force set up through suitable levers by a rotating governor, belt driven from the stoker drive shaft. A change in master load pressure creates an unbalanced condition in the regulator which causes an increase or decrease in stoker speed by changing the position of a piston operated lever attached to the stoker drive mechanism, until the regulator is again in balance.

Similarly, master pressure to the air volume regulator is balanced against the draft differential through the boiler, and the piston-operated lever is linked to the louvre dampers in the fan outlet. Simultaneously with stoker speed changes, the air volume regulator changes the position of the dampers, thus the volume of air to the stoker.

In the furnace draft control, the draft it is desired to maintain is balanced against a weight loaded lever, and the piston operated lever of the regulator is connected to the stack damper. Changes in the volume of gases to be handled, caused by changes in air volume and fuel feed, unbalance this regulator, which is

in balance again when the stack damper reaches its proper position.

The pistons of the regulators are actuated by oil pressure at 90 lb. ga., which, with the air pressure for the master control, is furnished by an oil pump and a blower direct connected to both sides of 5-hp. motor, all mounted on a common base.

Ash Disposal

For the next and final important operation, namely ash disposal, an hydraulic ash handling system was installed. The distillery is located adjacent to a ravine which provides storage space for ashes for 5 yr. The company also owns property adjacent to this ravine upon which ashes may be stored near the railroad right-of-way. The boilers are installed on the second floor of the boiler plant, thus providing room for refractory lined ash hoppers of sufficient capacity for 12 hr. run at maximum rating, beneath each unit. Twice a day the ashes accumulated in the ash hoppers are sluiced into a sluiceway beneath the hoppers, thence by means of sluiceway nozzles to a wet sump at the end of the basement. Duplicate ash disposal pumps are located here, each taking suction from the wet ash pit and elevating the ashes 10 ft. to grade, then transporting them a distance of 400 ft. to the point of disposal. Each pump has a capacity of 900 g.p.m. of water and ashes. This enables the boiler operators to dispose of the entire day's ash production in approximately 1.5 hr.

The ash disposal pumps are operated by a float actuated pressure switch, so that they automatically act as bilge pumps to remove the ash quenching water, as well as any seepage which may enter the basement during flood stages of the Illinois River. The ash pumps, sluiceway liners and discharge pipe are made of an alloy capable of withstanding the highly abrasive action of the ashes for a minimum of 10 yr.

This system permits maintenance of the boiler house basement in a clean and sightly condition, as the ash hoppers and sluiceway are dust tight; and the quench nozzles in the hoppers continually saturate the ashes as they are discharged from the stoker grate. Water required for sluicing and transporting the ashes through the pumps, approximately 900 g.p.m., is supplied by a duplex steam pump in the boiler room basement. This pump utilizes waste water from the hot well of the barometric condenser operated in conjunction with the evaporators previously mentioned in this article.

Boiler auxiliaries are conveniently located on the firing floors. The boiler feed pumps are equipped with excess pressure governors, which in conjunction with the thermal tube type feedwater regulator on each boiler require a minimum of operating supervision. The water softeners are adjacent to the feed pumps and directly beneath the feedwater heater. Each softener is furnished with an alarm equipped meter which registers the gallons of water through the softeners, with the alarm set to operate at a point well below the capacity of each unit. Salt for regeneration is stored in a wet storage pit of 40 t. capacity just outside the boiler house, with openings at box car floor level to facilitate the transfer of bulk salt from the car to storage. Just prior to regeneration of a softener, sufficient brine is pumped from the wet storage to a saturating tank located adjacent to the softeners and is then injected into the softener to be regenerated.

An instrument board, incorporated with the combustion control master panel, is located at the end of the firing aisle near the feed pumps and softeners, permitting the operator to check the functioning of the controls and the operation of the auxiliaries at the same time. It is also a convenient means of obtaining data regarding temperatures, pressures and flows of steam, feedwater and condensate returns for the hourly operating log sheet. A daily record is kept of the amount of fuel burned and daily samples of coal obtained for analysis. The operating data thus compiled is a practical daily boiler test of overall efficiency for the house, and insures against fuel waste much more positively than individual boiler tests run at intervals.

The operating work schedule is so arranged that neither of the two men who constitute the operating force are unduly rushed at any time, even though their duties cover not only the operation of the entire steam plant, but also include the handling of all fuel from the cars to the stokers, the disposal of ashes to the ash dump and the operation of the water softening plant.

List of Equipment, Century Distilling Co.

Turbo-Generators—Allis-Chalmers Mfg. Co., two, 3600 r.p.m. units operating at throttle conditions of 150 lb. ga., 75 deg. F. sup. One turbine operates condensing with automatic extraction at 5 lb. ga., the other operates against a back pressure of 15 lb. ga. The condensing turbine drives a 750 kw., 0.80 p.f., 480 v., 3 ph., 60 cycle generator and a 120 v., 72 amp. direct connected exciter. The non-condensing turbine drives a 625 kw., 0.80 p.f., 480 v., 3 ph., 60 cycle generator with a 120 v., 72 amp. direct connected exciter.

Switchboard—General Electric Co., 16 panel complete with synchronizing panel, voltage regulator and instruments.

Turbine Panel—Made up of Brown recording thermometer on condenser water discharge temperature; Brown Instrument Co. recording vacuum gage on No. 2 turbine; Foxboro Co. clock; Jas. P. Marsh Corp. indicating pressure gages on extraction and back pressure steam lines.

Air Compressor—Worthington Pump & Mach. Corp., 14 by 15 by 16 in., steam driven, operating at 210 r.p.m., against a pressure of 80 lb. Equipped with Manzell Bros. lubricator and Erie governor.

Crane—Whiting Corp., 7½ t. hand operated.

Reducing Valve—15 to 5 lb. Atwood & Morrill.

Traps—W. H. Nicholson & Co.; Strong, Carlisle & Hammond Co.

Boilers—Babcock & Wilcox Co., four, 500-hp. Stirling boilers, operating at 150 lb. ga., 100 deg. superheat.

Stokers—Laclede Stoker Co., four chain grates, driven by General Electric 3-hp., 1750 r.p.m. motor through a Reeves Pulley Co. transmission. Grate area 108 sq. ft. each.

Forced Draft Fans—Buffalo Forge Co., four, capacity 15,000 c.f.m. each, driven by General Electric 10 hp., 1155 r.p.m., 440-v. motors.

Overfire Air Fans—Buffalo Forge Co., four, each driven by a G. E. 3 hp., 440-v., 1720 r.p.m. motor.

Combustion Chamber—Bigelow-Liptak Corp. Flat suspended ignition combustion and rear arches. Unit supported air-cooled side, rear and front curtain walls.

Feedwater Heater—Cochrane Corp., deaerating storage type, capacity 110,000 lb. per hr.

Boiler Feed Pump—Ingersoll-Rand Co., two, 250 g.p.m., operating at 3450 r.p.m., one driven by a 50-hp. General Electric 440-v. motor, the other by an Elliott Co. 50-hp. steam turbine with a Fisher Governor Co. pump governor.

Water Softener—Graver Tank & Mfg. Corp. Zeolite system.

Ash Sluice and Hoppers—Allen-Sherman-Hoff Co.

Ash Pump—Allen-Sherman-Hoff Co., two, Hydroseal pumps with a capacity of 1000 g.p.m. at 860 r.p.m. Driven by General Electric 50-hp. vertical motors.

Sluice Pump—Worthington Pump & Machy. Corp., one, 16 by 14 by 18 in. horizontal duplex.

Coal Handling—Beaumont-Birch Co., consists of a 40 cu. ft. skip hoist, 280 t. bunker and a 2 t. weigh-larry.

Blowoff Valves—Yarnall-Waring Co.

Combustion Control—Smoot Engineering Co., system incorporating an oil pump and a Commercial Blower Co. size 9½ in. blower with a Protectomotor filter, both driven by one 5-hp., 440-v. General Electric 860 r.p.m. motor. Control panel incorporates master control and 7 Brown Instrument Co. indicating and recording instruments.

Feedwater Meters—Builders Iron Foundry, Venturi meter.

Feedwater Regulator—Northern Equipment Co., Copes.

Draft Gage—Ellison Draft Gage Co., four, 8 pointer gages.

Safety Switches and Panel Boards—Square D Co.

Valves—Crane Co.

Government Power Projects

Careful analysis of the individual projects is needed to determine whether or not they are justified and on what grounds

IN CONSIDERING government's plans for development of power projects, two questions are of prime importance: What is the object of the developments? Can they be justified on economic grounds or as a matter of public welfare? The last point, public welfare, is capable of various interpretations but may reasonably be included under four heads: flood control, improvement of navigation, reclamation of land by irrigation, control of power supply and cost to consumers.

To get an understanding of what is proposed, it is necessary to examine the list of projects, then consider each one for the answers to the two prime questions.

The chief developments now under way and proposed are: Boulder Dam in Nevada; Tennessee River in the southeastern states; Grand Coulee and Bonneville Dams on the Columbia River, in Washington and Oregon; Fort Peck Dam on the Missouri River in Montana; Caspar-Alcova project in Wyoming; Verde project in Arizona; Owyhee project in Idaho and Oregon; Loup River Dam in Nebraska; Monongahela River Development in West Virginia; Wabash Valley Authority in Illinois and Indiana; Arkansas Valley Authority in Arkansas and up the river; Mississippi Valley Authority, covering the Mississippi and Missouri Rivers from St. Louis north; St. Lawrence Waterway on the St. Lawrence River.

To get an idea of the need for power from these developments, it is useful to tabulate the power supply now available in the various sections, the capacity which will be added by the government projects and the recent demand for power. Projects not tabulated have not yet been worked out in sufficient detail to define the capacity to be installed or the area to be covered, but estimates of cost are available, and relation of present capacity to demand falls within the range of those tabulated.

Obviously, so far as need for power is concerned, either present or for a considerable time in the future, there is no occasion for any of the Federal projects and their operation can only result in reducing the output of present plants that are already badly underloaded or in meager load on the new plants or both. The result must be competition of the government with private business on a distinctly unfair basis, since the Federal projects will pay no taxes, are financed by low-interest government bonds and will have the weight of government and political influence to secure customers.

Considering the cost of the various developments, as estimated and appropriated, they are as shown in the accompanying table.

What proportion of the present demand will be supplied by the Federal projects is a matter of guess, but, except in case of the smaller plants, there is little likelihood of their having any adequate load for many years to come. Meanwhile, the taxpayers of the country will be paying for overhead and upkeep.

As to public welfare elements, Boulder Dam has flow control as an object, but that could have been accomplished at an expenditure of some $50,000,000. Tennessee River is frankly a social experiment as the head of the TVA has stated that there is plenty of power available for present demands, that it is impossible to ascertain where additional power will find a market, that he has no estimate of income to be derived from sale of power nor of income needed to cover carrying charges and amortization, but that it will be some time before the program will be self sustaining. In other words, the cost of the experiment must be carried by taxation, to a considerable extent.

Of the other plants, the Grand Coulee project, Ft. Peck, Caspar-Alcova, and Verde have plans for irrigation, 1,200,000 a. at Grand Coulee, 66,000 a. at Caspar-Alcova. The Wabash, Arkansas and Mississippi River projects are tentatively planned along the same lines as TVA. Verde is to cut into the water now going to Roosevelt Dam irrigation district, which now has barely sufficient for the land under cultivation. Meanwhile the government is paying bonuses to have land kept out of use.

In practically none of the projects, except the Tennessee River and possibly the Columbia, does improvement of navigation enter.

Capacities and Demand at Government Power Projects

	Kw-hr. per year at 50% capacity		Kw-hr. per year used, 1932	Per Cent of Capacity to demand	
	Present Plants	Federal Plants		Present Plants	Combined Plants
Tennessee River	14,040,526,000	8,760,000,000	6,362,219,000	221	358
Boulder Dam	7,210,137,000	4,380,000,000	4,128,790,000	175	281
Grand Coulee	5,064,156,000	2,277,600,000	3,181,883,000	159	231
Bonneville	5,344,038,000	1,883,400,000	3,427,935,000	156	211
Ft. Peck	1,648,632,000	1,752,000,000	770,286,000	214	442
Caspar-Alcova	1,558,404,000	140,160,000	764,124,000	204	222
Verde	1,376,415,000	376,680,000	489,501,500	281	358
Loup River	5,479,818,000	210,240,000	2,987,612,000	183	191

Cost of Government Projects

	Total Cost Estimated	Assigned to Navigation, Flood Control or Irrigation	Alloted to Date	Cost per kw. Capacity
Boulder Dam	$165,000,000	$ 56,000,000	$165,000,000	$ 71
Tennessee River	367,000,000	167,000,000	156,300,000	100
Grand Coulee	63,000,000	.....	15,000,000	126
Bonneville	43,900,000	.....	31,250,000	362
Ft. Peck	59,000,000	.....	50,000,000	147
Caspar-Alcova	22,750,000	12,700,000	12,200,000	107
Verde	18,912,000	.....	4,000,000	...
Owyhee	18,000,000	.....	6,500,000	...
Loup River	7,300,000	.....	7,300,000	114
Monongahela	288,000,000	.....	10,000,000	262
Wabash Valley	60,000,000	.....	.....	...
Arkansas Valley	50,000,000	.....	.....	...
Mississippi Valley	No limit	.....	.....	...
St. Lawrence	900,000,000	.....	.....	...

Except for flood control, where power developed may be a by-product, it is difficult to justify the developments on any ground of public welfare unless as in TVA it is desired to try an experiment and the cost be charged to social research. So far as establishing a "yardstick" for rates on electric supply, it can hardly be logical to set up the cost in a 500,000-hp. hydroelectric plant as a standard for a 50,000-hp. steam plant, even though, with like basis of overhead on the two, the smaller plant might not suffer by comparison. Control of local rates is easily set up by state public service commissions without doing vital harm to the interests of thousands of investors in private utility securities or loading taxpayers with a heavy burden for years ahead.

The Federal developments are for the most part remote from centers of population or industry. Power load will develop slowly and present capacity is ample. As Col. Hugh L. Cooper told a House Committee, "You cannot put a million horsepower into a market just by dumping it." The fact that reports of engineers have been unfavorable as to the economy of many of the projects would seem to be good reason for going carefully, if at all. Unless economics and public needs justify the developments, what has been or can be their justification?

As a partial answer to the question, information comes that Secretary of the Interior Ickes has determined that the Rio Verde project shall be abandoned as a mistake. It is to be hoped that the other projects will be carefully examined to see whether they also are mistakes.

Welding *and the* Boiler Code

Present Code Permitting Welded Drums Is the Result of 10 Yr. of Effort

IN AN ADDRESS before the local sections of the American Welding Society Dr. D. S. Jacobus, president, outlined the history of welding, particularly in connection with its relation to the Boiler Code. The first A.S.M.E. Boiler Code was published in 1914 and sanctioned the use of fusion, or as it was then called, autogenous welding, but only where the stress or load was carried by other construction which conformed to the requirements of the code and where the safety of construction was not dependent upon the strength of the weld.

Extension of welding and the formulation of rules to allow more extensive application was a long drawn out process. In March, 1920, a council of the A.S.M.E. requested the A.W.S. and the A.S.R.E. to appoint committees to co-operate with the Boiler Code Committee in the preparation of rules covering fusion welding, with the idea of incorporating these in the Boiler Code. Co-operation of the other societies with the Boiler Code Committee was a logical development as the Boiler Code had been legally adopted by a number of states and municipalities and those in charge of its enforcement had jurisdiction over boilers and pressure vessels.

Welding First Allowed on Unfired Vessels

In 1927 the Boiler Code Committee prepared a set of rules for fusion welded unfired pressure vessels without the approval of the A.W.S. At this time the term, "fusion welding," was first used by the Boiler Code Committee. The maximum stress allowed was 5600 lb. per sq. in. and welding was limited to air vessels not over 20 in. in diam. and with a working pressure of not over 100 lb. per sq. in., or for circumferential joints.

In 1927 the state of California formulated a code for unfired pressure vessels to become effective January 1, 1928. The allowable stress for butt-double-V-longitudinal welds was raised to 8000 lb.; the limiting inside diameter for air vessels was raised from 20 to 60 in.; and the pressure raised from 100 to 200 lb. per sq. in. This change was made in coöperation with the Boiler Code Committee.

Agitation for more liberal welding rules continued and the A.W.S. arranged with the Boiler Code Committee for a conference to discuss a series of tests to be made at the Bureau of Standards in Washington to convince the Boiler Code Committee that welding could be used for such purposes as the drums of power boilers. Lack of funds made it impossible to carry this project through. Tests along these lines were, however, carried through by one manufacturer and reported at the semi-annual meeting of the A.S.M.E. in June, 1930. These tests demonstrated the dependability of properly made fusion welds and established the working stresses which could be safely used.

X-Rays Used for Testing

Several nondestructive tests of fusion welds were investigated and X-rays found to be effective for this purpose. In March, 1930, proposed specifications for fusion welding of drums or shells in power boilers were first published, and in August, 1930, the Navy Department issued specifications, which gave an impetus to the use of fusion welded boilers. These specifications included a requirement that all main seams were to be X-rayed.

In 1931 the Boiler Code published the rules for fusion welding of drums and these rules were followed the same year by the revised rules for fusion welding of unfired pressure vessels. In January, 1932, the A.W.S. committee modified the marine boiler rules to meet the requirements of the Steamboat Inspection Service. Another set of welding rules is embodied in the A.P.I.-A.S.M.E. rules for the design, construction, inspection and repair of unfired vessels for petroleum, liquids and gases.

Rules formulated so far cover only a small part of the welding field. Rules are needed in other fields such as bridge building, ship construction, the replacement of castings by welded plates, welding of piping, gas cutting and related developments. A great deal of work has already been done in these fields and the proposed Standard Code for Pressure Piping, which includes welding rules will shortly be issued by the A.S.A.

Electric Eye *Looks Over Power Plant*— Saves $2622 a Year

By Morgan Farrell

THEY PUT an electric eye into the boiler breeching of the Rex Cole Building at 265 Fourth Avenue, New York City, to watch the smoke and sound an alarm, when there was too much of it. Before they got through, however, the owners found that the elimination of the smoke saved them $2622 a year in fuel cost alone. This is how it started:

The building is a well-kept, modern twenty-story office building with show rooms on the first floor containing electrically operated sample refrigerators, four elevators and its own power plant. This last is now excellently equipped and operated. It is kept always bright and clean and shows an efficiency so great that the owners do not consider that there is anything to gain by purchasing either electric power or steam or both from the public service corporations supplying them.

This story, however, is concerned only with fuel saving and the part the electric eye played in effecting it; so, for the present the owner's statement that his costs are less than those of purchased power may be accepted.

New York City authorities are usually both prompt and strict in the notification and punishment of violations of the smoke ordinance. In fact the neighbors of a visibly smoking chimney are not a bit hesitant about calling up the police and reporting it. For that reason operators of steam plants within the city limits are keen for smoke-abating and smoke-detecting devices.

To be on the safe side the manager of the Rex Cole Building investigated a number of smoke-detection devices and finally decided upon the installation of a Weston photronic cell in the main breeching of the boiler room.

The principal units of the steam plant are:

3, 150 hp. Titusville return tubular boilers, 100 lb. pressure.

2, Ball four-valve, high-speed engines, 16 by 22 in., 200 r.p.m. direct connected to 125-kw., 220-v. direct current generators.

1, Ball engine, 13 by 18 in., 250 r.p.m.; 75-kw. generator.

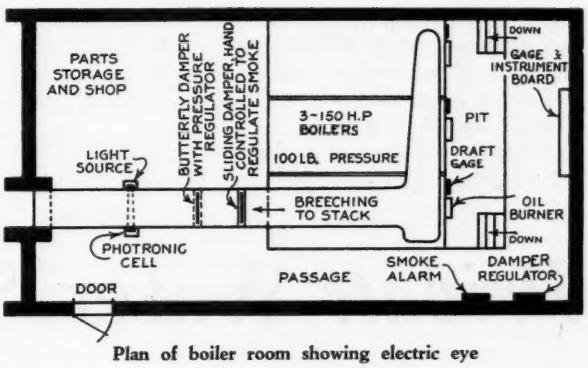
The electric eye installation is very simple. The constantly burning light source, a small concentrated-filament electric lamp with reflector and focussing lens, is enclosed and supported by a bracket on one side of the breeching, which, by the way, is over 75 ft. long beyond the boilers. Its ray falls on the photronic cell on the side opposite. This cell is extremely sensitive, self-generating so that it requires no outside source of current, and powerful enough to register without the interposition of an amplifying apparatus.

It therefore operates upon the appearance of even a thin film of smoke corresponding to the finest standard screen and acts directly upon a small indicating relay which rings a 4-in. alarm bell and, at the same time, turns on a light on a panel on the wall of the firing-room floor. The fireman on duty immediately takes the necessary steps to see that the smoke is consumed in the fire-box and combustion chamber.

When the smoke-detector was first installed the boilers were fired with coal, practically all the usually economical sizes and kinds being used. But, whatever the kind of fuel and the method of firing and consuming it at a moderate rate, it seemed impossible to do away with the smoke. When it was first put in, the smoke-alarm was ringing almost constantly. Nothing would stop it but to open up the dampers wide, which was impractical under a highly fluctuating power load like that of an office building with its complement of elevators. The cell was accordingly made less sensitive by means of a filter and the management settled down to figure out a solution.

Oil Replaces Coal as Fuel

The decision to convert the boilers into oil-burners went a long way toward correcting the smoke trouble.



Plan of boiler room showing electric eye

A Todd system of oil-burners and heaters was put in. The fuel oil is delivered at the burners under a pressure of 100 lb. per sq. in. Nothing was done to the boiler settings except to alter the lower part of the fronts to accommodate the oil-burner units. The omission proved to be a mistake, which had to be remedied later—a good thing to bear in mind, when changing over to oil-burning.

As soon as the oil-burners started to operate, the smoke condition was appreciably better. Still it was far from satisfactory. Surely, with a properly controlled oil-burning system there should be no smoke at all. Then followed more study and more investigation, resulting finally in the conclusion that there were two grave causes of the incomplete combustion, and, most likely, of a considerable loss of fuel.

Tests were made which showed that all the boiler settings were leaking badly because of cracks and disintegration of the fire-brick lining, the fire-clay and cement joints of the brickwork. This condition resulted in the oil-burner blowers delivering too much

air for combustion to make up for the leakage. The first purchase to be made was an indicating draft-gage for each boiler. These showed a draft varying from 0.45 to 0.60 in.

Meanwhile the electric eye was faithfully reporting too much smoke several times in an hour. Once in a while it would send off a prolonged alarm, which usually meant that one of the burners had gone out through improper handling or extreme operating conditions.

Boiler Setting Repaired

It was a hard decision to make but the boilers had to be relined and the outside settings repaired and pointed up. This was done during the summer. It is significant of the improvement immediately perceptible that, while only one boiler could be shut down for lining because the other two were needed, that one boiler carried the whole load with some forcing after it had been relined. So the other two were shut down together and conditioned.

To make the job complete the boilers were entirely cleaned of scale at this time and thenceforward a recognized compound was daily added to the feed, with the result that no additional scale has formed in a year.

At the same time the engines were taken down for the first thorough overhaul in more than 20 yr. To the general astonishment, the cylinder wear was only 0.006 in. and the rotary valve wear even less. The engineer in attendance attributes this to the systematic and generous use of first-rate lubricants in the cylinders and valve-chests as well as the cross-heads, wrist and crank-pins. The piston rings and cylinder walls were as smooth as glass.

Thus far did the watchful electric eye go in enjoining a complete overhaul. It is seldom called upon now to sound a smoke alarm even though its vision has been restored to its original sensitivity by the removal of the filter. A glance of the human eye through the nearby peep-hole shows the breeching altogether clear of smoke. One can see only the heat-waves of the escaping gases against the light.

On the rare occasions when the alarm does sound, a sliding damper is opened by hand from the firing floor, which cuts the pressure of the oil fed to the burners to 25 lb. from 100 lb. There is a second damper in the breeching operated by the steam pressure. If the pressure goes down and does not rise fully after this damper opens, then the sliding damper must be opened by hand. A method of making this operation automatic is being studied.

Resultant Fuel Economies

In the first place the draft has been cut from 0.45-0.60 in. to 0.18-0.25 in. representing about 60 per cent reduction in the air of combustion.

In the first week of June, 1933, before all these changes had been made, the total consumption of fuel oil was 4311 gal. or 616 gal. a day. One year later, the outside temperature averaging the same, the weekly consumption was 3805 gal. or 543 gal. a day. Saving: 73 gal. a day at 4 cts. = $2.88.

In February, 1933, the average daily fuel consumption ran to 1163 gal., the outside temperature being 33 deg. F. In February, 1934, the corresponding consumption was 860 gal. and the temperature 21 deg. F. Even without correcting for the temperature the saving is 303 gal. at 4 cts. = $12.12 a day.

The figures for the savings effected during the twelve months since the chain of betterments set in motion by the vigilant, smoke-observing electric eye has been $2,622.50.

Private Water Supply Problem

Method of Calculating Proper Size Pump and Reservoir. By K. B. Humphrey

FIGURING out the proper system of water supply for a given situation is a problem often passed on to the pump salesman without any check whatsoever. Some of these salesmen are well qualified and will give the buyer a system which is adequate and without question, the best. Other salesmen are primarily salesmen intent on selling their goods regardless of the actual needs of the buyer.

It is needless to say that a pump salesman should have somewhat of an engineering background in order to render real service. While the problem of water supply is more or less a specialized problem in engineering, the average maintenance man should be able to check up some of the figures submitted. In any case it is well to get the recommendations of several different salesmen on the job.

Suppose you have a proposition like this. A manufacturer requires for 6 hr. each day a flow of 200 g.p.m., during the remainder of the 24 hr. it is estimated that 20 g.p.m. will be required. In an actual case these figures may be estimated by the salesman or by the plant foreman, or the quantities may be obtained by readings on the water meter if the supply previously came from some outside source. If the water is metered, readings should be taken each hour, and if there are variations from day to day, at least a week should be taken. More often the quantities of water are only approximate and it is always well to figure high rather than low in such cases. It often pays to go into this matter rather thoroughly unless definite and reliable information is available. Supposing, however, that the maximum requirement is 200 g.p.m. for 6 hr. or less and that the shortest period between the 6 hr. maximum demand is 14 hours. This is the condition which would hold if the maximum period happened to be shifted from say an 8 o'clock

start to a 12 noon start, and then back to an 8 o'clock start the next morning.

The questions to be answered are: What size pump to install and what size should the storage capacity be if any. The question of the size of pump will be taken up first. Pressures need not be discussed as the discharge of the pump and the size of motor will vary considerably under different heads. It is only necessary to take into consideration the g.p.m. capacity of the pump. A single pump could be obtained with a capacity of 200 g.p.m., but this pump (without storage capacity) would have to run the full 24 hr. without a stop and the efficiency would be low during the greater part of the time.

Two pumps could be installed, one having a 200 g.p.m. capacity and the other a 20 g.p.m. capacity. They would be run alternately according to the demand for water. Ordinarily two pumps would not be used on account of the cost though the efficiency would be much improved over that of a single pump. A single pump could be installed with a variable speed motor to give the desired maximum and minimum capacities. The two speed motor is expensive and the cost would not be much less than for two separate pumps and the efficiency at one speed or the other would suffer.

Pump and Reservoir Capacities

It is obvious that some sort of storage arrangement will probably work out best. The question then is to decide the size of the pump required in conjunction with a storage reservoir. During the maximum day there would be required 200 g.p.m. for 6 hr. or $6 \times 60 \times 200$ or 72,000 gal. For the rest of the 24 hr., $18 \times 60 \times 20$ or 21,600 gal. would be required. The total amount of water required during the 24 hr. would be 93,600 gal. Allowing a margin we will say that 100,000 gal. are required every 24 hr. There are 1440 min. during the day and dividing 100,000 by 1440 gives us the g.p.m. required (69) or practically 70 g.p.m. This is the capacity of a pump which would work the full 24 hr.

The capacity of the storage tank would have to be figured as follows: While the pump is supplying 70 g.p.m. during the peak period when 200 g.p.m are being used there is a deficiency of 200 minus 70 or 130 g.p.m. or a total deficiency of water of $6 \times 60 \times 130$ or 46,800 gal. per min. which would have to be supplied by the tank. A 50,000 gal. tank approximately would be 22 ft. in diameter by 20 ft. high (wooden round tank).

This capacity, however, would give very little leeway. The problem states that the closest period in which a 6 hr., 200 g.p.m. run may occur is 14 hr. If this should occur the tank would be only partially full at the start of the run. Pumping 70 g.p.m and using 20 g.p.m. would leave only 50 g.p.m. to fill up the tank and in 14 hr. the amount of water in the tank would be $14 \times 60 \times 50$ or 42,000 gal. As 46,800 gal. are required for the 6 hr. run the deficiency would be 4800 gal. As these 4800 gal. are required extra during the 6 hr. run the g.p.m. deficiency would be 4800 divided by 60×60 equal to 13.3 g.p.m. That is, to meet this condition the pump should have a capacity of 70 plus 13.3 or 83.3 g.p.m. This would be the minimum capacity of the pump to meet actual conditions. It can easily be seen that the storage tank is disproportionally large and it might be well to consider a larger pump with less storage capacity.

System Using 200 g.p.m. Pump

Suppose we figure out a system using a 200 g.p.m. pump which would operate steadily for a period of 6 hr. a day and then by means of a float in a smaller storage tank take care of the lesser amount by running intermittently the rest of the day. If only a 5000 gal. capacity storage tank is used, the 200 g.p.m. rate could be kept up for 5000 divided by 200 or for 25 min. without the pump, operating at all. This would give enough leeway for minor repairs. Again without the pump running 5000 gal. would last 250 min. at the 20 g.p.m. rate. This would give considerable time in which the pump would not operate.

During a normal day with say a float on the tank which would start the pump whenever the water capacity dropped to 2500 gal., or half way, the pump would run at full capacity after the tank had dropped 2500 gal. or after a period of 12½ min. The pump would then run for 6 hr. straight at full capacity. After the peak period was over and the 20 g.p.m. rate was being used the pump would shut down for 125 min., operate for about 14 min. and then shut down again for 125 min. That is, the pump would have to operate about 15 min. after every 2 hr. of water use.

Probably the whole question would settle down on a price proposition. If a large storage reservoir plus a small pump would be cheaper to install than a large pump and a small storage tank. Either way would work. In some cases the size of the well would be the limiting factor. In other cases the small sized pressure tank would fit in with existing conditions. In still other cases a storage tank may be available or the conditions around the plant might make it feasible to install a large open tank on the roof. At any rate it is perfectly practical to figure out the operating conditions beforehand and check up on the salesman before the order is signed.

Reduced Fuel Costs

Chief Engineer E. O. Carichner of the Illinois Athletic Club, Chicago, reports satisfactory savings due to new boiler room equipment and improved operating conditions.

Automatic firing with a Link Belt Stoker replaced hand firing to feed 1200 lb. of coal an hour to the Edge Moor 175-hp. water-tube boiler, the coal used costing $4.70 a ton at a saving of $2.70 a ton over hand firing. Load carried is heating, ice-machines, hot water supply and pumps. Coal is delivered by chute to the stoker hopper, then by screw conveyor into the furnace. Coal feed and forced draft are controlled electrically to maintain 90 lb. pressure. Underfeed stoking results in smokelessness and low ash production, the saving in cost of ash handling being $80 a month.

Mr. Carichner states that cost of steam now averages 29c per 1000 lb. and that with all savings due to the stoker credited against the cost of the installation, it will be paid for in 6 mo.

Surface Condenser
Design and Operation

Investigation of Surface Condenser Performance Shows That Pressure Drop in Condensers Greatly Influences Their Performance and That the Commonly Used Simplified Grashof Formula for Temperature Difference Should Never Be Used. By H. L. Guy and E. V. Winstanley*

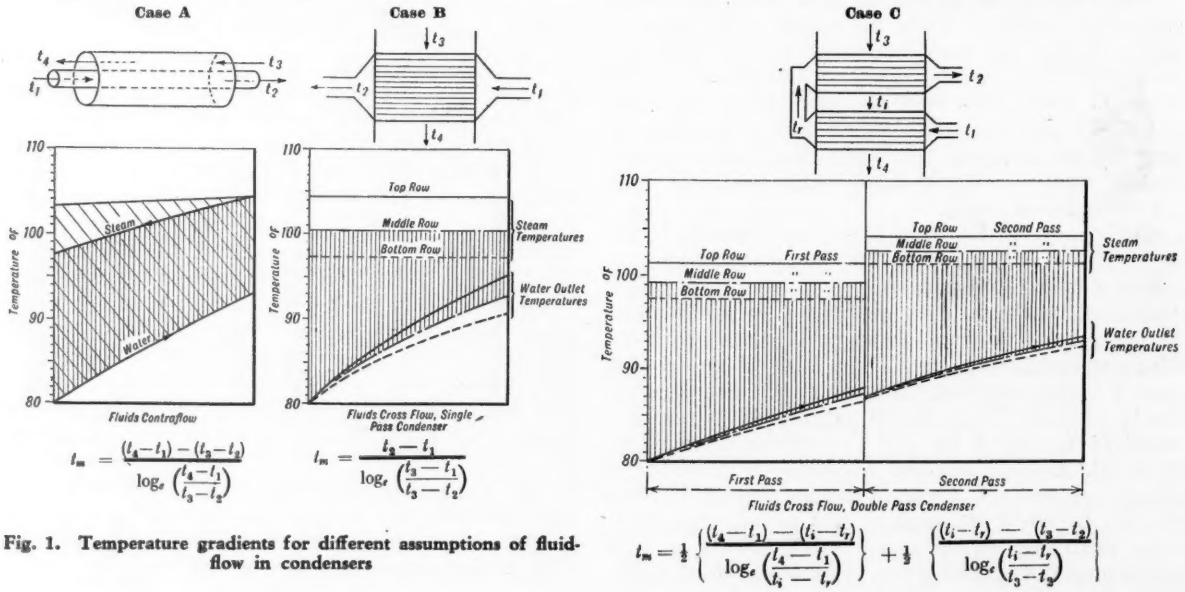
PROGRESSIVE INCREASE in the size of power plant units during the last 20 yr. has necessitated not only a reconsideration of the accepted methods of approach to the design of condensers but also the introduction of fresh factors and a new conception of what actually takes place in the condenser. The gradual increase in size of plant was a world-wide movement, and the first considerable growth in size of condensers, accompanied as it was by the development of the technique and practice of accurate testing, disclosed many cases of disappointing results. The apparent rate of heat transmission deduced by the method then employed by condenser designers appeared to be alarmingly less than had been obtained in smaller condensers.

In various parts of the world it was found that in large plants the actual vacuum was from ¼ to ¾ in. less than could be reasonably expected. It must be remembered that between 28 in. and 29 in. of vacuum, ½ in. of vacuum corresponds to a difference of 2½ to 3 per cent in steam consumption, so that the financial loss (on important plants) was considerable. In many instances it was found that the vacuum in a particular condenser could be materially improved by removing 20 to 30 per cent of the tubes.

Careful measurement clearly revealed that in all cases where the actual vacuum was disappointing there was a considerable drop in steam pressure in passing across the tubes and a number of investigations suggested certain dimensional factors which might control its magnitude. Further, a simple mathematical investigation suggested a way in which these dimensional factors might be expected to be co-ordinated. A number of condensers were then selected varying sufficiently to provide a reasonable test of the hypothesis which had been built up.

These investigations started with the expectation that the drop in pressure would depend not only on the square of the velocity of steam between the tubes and upon the density of the steam, but also upon the number of tubes crossed before condensation was complete. For the same tube plate efficiency the tubes may be disposed in a variety of ways. One of the first steps taken to control and reduce the pressure was the replacement of the older down-flow type of condenser by a central-flow condenser in which steam is given access to the whole periphery of the tube nest by the provision of a volute enclosing the nest, all steam

*Abstract of a paper read before the Institute of Mechanical Engineers. Both authors are connected with the Metropolitan Vickers Electric Co., Ltd., of Manchester, England.



$$t_m = \frac{(t_4 - t_1) - (t_3 - t_2)}{\log_e \left(\frac{t_4 - t_1}{t_3 - t_2}\right)} \qquad t_m = \frac{t_3 - t_1}{\log_e \left(\frac{t_3 - t_1}{t_3 - t_2}\right)}$$

$$t_m = \tfrac{1}{2}\left\{\frac{(t_4 - t_1) - (t_i - t_r)}{\log_e \left(\frac{t_4 - t_1}{t_i - t_r}\right)}\right\} + \tfrac{1}{2}\left\{\frac{(t_i - t_r) - (t_3 - t_2)}{\log_e \left(\frac{t_i - t_r}{t_3 - t_2}\right)}\right\}$$

Fig. 1. Temperature gradients for different assumptions of fluid-flow in condensers

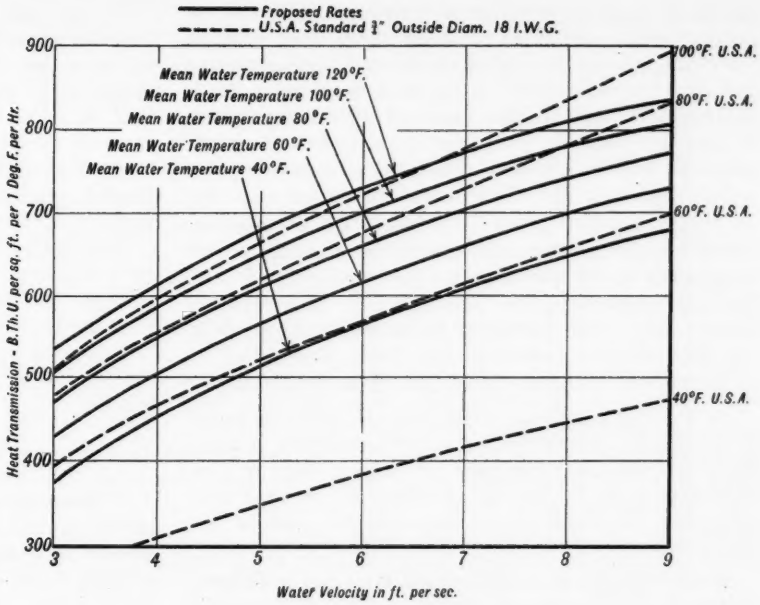


Fig. 2. Rates of overall heat transmission for ½, ⅝, ¾ and 1 in. O.D. condenser tubes

lanes being eliminated. In a later development radial pitching of the tubes was substituted for triangular pitching in the outer rows.

The pressure drop P in inches of mercury is given by

$$P = CD\ (U^2_E \div V) \qquad (1)$$

Where C = Experimental coefficient (which graphs in the original paper show varies from 0 to 0.05

D = Diameter of the tube nest in feet

V = Specific volume corresponding to vacuum at condenser inlet

$$U_E = QV \div \left[LD\ (1 \times \frac{d}{p} \sqrt{n}) \right] \qquad (2)$$

Where Q = Steam flow in pounds per second

L = Length of tubes between tube plates in feet

d = O. D. of tube in inches

P = Mean tube pitch in inches

n = Tube plate efficiency (the ratio of the actual number of tubes to the possible maximum with the mean pitch used)

Directly the presence of the pressure drop in the steam side of the tube nest was appreciated and its magnitude known, it became necessary to examine how it influenced the exchange of heat across tubes at different parts of the tube nest. The heat transmission coefficient in a condenser is obtained from the formula—

$$K = (Q \times h_c) \div (t_m \times S) \qquad (3)$$

Where Q = Steam flow in pounds per hour

h_c = Heat abstracted in the condenser in B.t.u. per lb. = $h_2 - h_4$

h_2 = Total heat per pound of steam at entrance to the condenser in B.t.u. per pound

h_4 = Sensible heat of the condensate in B.t.u. per pound

S = Condenser surface in square feet

t_m = Mean temperature difference causing heat flow across the surface in deg. F.

The well known Grashof formula for contraflow conditions is shown in the lower right hand corner of Fig. 1A. A simplification of this formula is common in condenser work and obtained by assuming the steam temperature is constant as shown by the top curve as in the upper left hand corner of Fig. 1A. This assumption is valid only if there is no pressure drop through the tube nest. Both of these formulae must be examined with respect not only to pressure drop but also to other departures from the conditions controlling the temperature gradients in a condenser from those assumed by Grashof in deducing them. In order to illustrate how the actual conditions in a condenser depart from the theoretical case assumed by Grashof, the curves Fig. 1 were prepared for a condenser maintaining a vacuum of 27.8 in. of mercury with 80 deg. F. inlet and 93 deg. F. outlet water temperature and a pressure drop of 0.4 of an inch of mercury. Case A illustrates Grashof's assumption of contraflow heat exchange with the further usual and implied assumption that these conditions apply equally to each and every tube in the condenser. Distribution of temperature gradient obtained in this way is shown in the area shaded vertically. The effect of the assumption which produces a simplified formula is shown by the diagonally shaded area of Case A and obviously leads to an apparently increased mean temperature difference.

Now in an actual condenser the flow of steam is across each row of tubes at right-angles to the direction of the water flow inside the tube, and while the temperature on the steam side of each tube is constant for the whole length of that tube, if there is a drop in pressure as the steam passes through the tube nest the steam temperature is progressively falling from one row of tubes to the next in the direction of steam flow.

Consequently the rise in the water temperature in successive rows of tubes is different and gets pro-

gressively less as one passes from one tube row to another in the direction of steam flow. The water is therefore leaving the tubes at different temperatures and it is the temperature after mixing which is the t_2 of Grashof's formula. The heat exchange in condensers is therefore of the cross-flow type shown diagrammatically in Fig. 1, Case B, for a single-pass condenser and is distinctly not of the contraflow type.

This cross-flow formula is based on assumptions which closely resemble the conditions actually occurring in the condenser. The temperature gradients for the middle row of tubes are shown by the vertically shaded area. The variation in temperature gradient top and bottom rows has also been plotted and a characteristic departure from Case A is apparent.

A further difference from the conditions assumed by Grashof is introduced directly departure is made from a single to a two-pass condenser. This is illustrated by Fig. 1, Case C, in which the shaded area gives the temperature gradient for the middle row of each case.

Deductions to be made from studies are as follows: In the case of single-pass condensers cross-flow formula nearly represents the actual conditions but gives a substantially different result from either of the more usually adopted Grashof formulae. It is possible that the apparently low rate of heat transmission which has been obtained occasionally on single-pass condensers arise not mainly from air blanketing nor from lower rates of heat transmission in the condenser itself, but from the fact that the formula used to determine the mean temperature difference gives a value which was appreciably in error.

For instance, consider the condition in the case of a condenser with inlet water temperature 80 deg. F., a water rise of 13 deg. F. and a pressure drop of 0.2 in. The conventional determination of t_m given by the first Grashof formula gives a value of 1.6 per cent greater than that given by the cross-flow formula. On the other hand, for a large pressure drop of 0.6 in., the conventional t_m would be over 16 per cent greater than the actual. At such water temperatures, therefore, unless pressure drops are encountered the discrepancy is not very great. If, however, colder water at 60 deg. F. inlet temperature is used in a single pass condenser and a pressure drop of 0.2 in., the conventional t_m is 7.7 per cent too great, while if the pressure drop is increased to 0.4 in., the conventional value would be 33 per cent too large.

In the latter case, therefore, if the conventional formula were used to analyze a test, the value of the rate of heat transmission which would be deduced would probably be only 75 per cent of the actual. Alternately, if rates of heat transmission obtained on small condensers are used as a basis in the design of large single pass condensers with 60 deg. F. inlet water temperature and a pressure difference of 0.4 in., the surface which would be supplied would be over 50 per cent too small.

For single-pass condensers, therefore, if serious errors are to be avoided, the Grashof formula which had been used formerly should be abandoned and the cross-flow formula adopted. The simplified formula should never be used for single-pass condensers.

In the case of double-pass condensers, it is found that the change introduced by the return flow brings all formulae, including even the simple arithmetic mean, much more closely into line with one another than was the case with the single-pass condenser. It can still be said, however, that the simplified Grashof formula should never be used because the even simpler formula giving the arithmetic mean provides on the whole a much closer approximation to the truth.

The authors feel, however, that in the case of two or three-pass condensers the conventional Grashof formula can be used without sensible error provided it is used both in the analysis of tests for the determination of rates of heat transmission and in design for the determination of surface on the basis of such rates.

Overall Heat Transmission

When overall values of heat transmission coefficients are calculated from experimental data it may be considered as being made up of two parts, the heat transmission from water to tube and from tube to steam. The first is a function of the water velocity and the mean water temperature. The second was, from experimental data, assumed to be a constant with a value of 1350 B.t.u. per sq. ft. per deg. F. per hr. From these values the total heat transmission given in full lines in Fig. 2 were obtained for the range of water velocities and mean water temperatures encountered in ordinary condenser practice. These rates of heat transmission can be obtained on commercially clean condensers of good design with some margin to cover reasonable departures from ideal conditions.

The dotted curves of Fig. 2 give the rates of heat transmission which were mutually agreed upon by the six principal U.S.A. condenser manufacturers. It is important to realize that the American curves are intended to be used with the simplified Grashof logarithmic mean temperature difference and without regard to the effect of pressure drop on the mean temperature difference. For no pressure drop and a mean temperature difference of 60 to 70 deg. F., the American values almost coincide with the authors' values while at 40 deg. F. the American value is so low that it suggests that it has been depressed to compensate indirectly for the effect of considerable pressure drop or that its determination was influenced by experience in single flow condensers where the Grashof formula gives too great a mean temperature difference.

Flying Speeds for regular service are increasing, the use of nickel steel of suitable grades contributing to the lightness and strength of various parts such as crank shaft, connecting rods, studs, cams, piston pins and rocker arms. A new monoplane for 10 passengers, built by the Airplane Development Corp. for American Airways, recently made an average speed of 241 mi. per hr. between New York and Chicago. The regular cruising speed is 215 mi. per hr., landing speed 60 mi. per hr. Power is a Wright Cyclone engine of 735 hp. and fuel capacity is sufficient for 1000 mi. run.

Utilizing Waste Heat *from Internal Combustion Engines*

By Abe Detweiler

SOME discussion of the article on this same subject in the February issue of Power Plant Engineering by H. F. Sheppard, it seems to the writer, is needed by readers for apparently the author's object was to point out the difficulties to be encountered in reclaiming any considerable portion of this waste heat and thereby explain why this is not common practice, which he did quite admirably. I would like to offer a few suggestions as to how these difficulties might be overcome.

With Diesel engines approximately 2000 B.t.u. per hp-hr. is lost to the cooling system, and about an equal amount of heat is lost in the exhaust, while about 800 B.t.u. are lost through radiation and other sources. This loss to the cooling system offers possibilities of the largest saving, for this heat can all be absorbed, in fact it is all being absorbed; whereas only a part of the exhaust heat can be absorbed, depending upon the cycle the engine operates on and other factors. A portion of the loss by radiation might also be absorbed. Sufficient heat could be recovered from these sources to generate 2½ lb. of steam or more per horsepower-hour. If this steam were generated at 40 lb. gage it would be sufficient to effect a saving in power of 10 per cent or more.

Forty pounds is a rather moderate steam pressure, but with a 28 in. vacuum, steam at 40 lb. is 75 per cent as efficient with respect to available energy as steam at 200 lb., and a turbine is well adapted to utilize low-pressure steam. The turbine could be operated in parallel with the large Diesel unit and would assume as much of the load as it could carry on the supply of steam available without the usual governing mechanism.

An explosion engine presents much the same conditions except that the possible savings are about 33 per cent greater. As exhaust boilers are being used, utilizing the exhaust heat will not be discussed here except to say that a part of the exhaust heat may be used for superheating.

Although the cooling system offers the greater possibilities of a heat saving, it also presents the greater difficulties. If one would approach an engine in service with a few steam fitter's tools, plug up the jacket, install a steam gage and a safety valve, run a steam pipe over to a turbine and reap a profit from the side line, no doubt complications would arise. The cooling system was designed to get rid of the heat, not to save it. But if the engine builders should design and construct the engine giving due consideration to the problems of utilizing the heat from the jacket as they must to other features, I believe they could be solved satisfactorily. But the designer must remember that he is designing not only an engine, but a furnace and boiler also.

At a steam pressure of 40 lb. the temperature will be 287 deg. F. This temperature of itself is not necessarily objectionable. Research work has been done to obtain a fluid to cool engines at higher temperatures, not in order to utilize the heat but to obtain better performance and necessitate less radiator surface area. But this higher temperature together with the formation of steam within the jacket constitutes a considerable difficulty. Here we might compare the problems at hand with those of boiler construction.

With the steam boiler we have a metal wall heated from one side by hot gases and cooled from the other side by a mixture of water and steam. With the engine jacket we have these same conditions with the additional requirements that a portion of the surface exposed to the hot gases must be lubricated, it must resist abrasion, and it must not be much distorted. To offset these additional acquirements—although the maximum temperature of the gases in the engine may be higher than with the boiler—the average temperature is lower due to the intermittent periods of combustion and the expansion of the gases. The temperatures in the boiler are considerably higher than the temperature assumed as acceptable in the jacket; and the metal of the superheater must be cooled entirely by steam.

Compare Engine Jacket to Steam Boiler

From these considerations it is seen that the problems connected with generating steam in an engine jacket are similar to those of a modern boiler. In the jacket, as in the boiler, it would be necessary to keep sufficient water circulating in contact with the heated metal so as to carry away the steam bubbles as they form on the metal surfaces and immediately bring the water in contact with the metal again. At frequent intervals, or after the water completes a pass up along the cylinder, the steam should be separated and removed and the water returned for another pass. The jacket must be designed to facilitate such circulation. If necessary the cylinders could be made with more surface area exposed to the cooling medium, and metals with more suitable thermal properties used.

Quite justly the question arises as to whether the saving effected by such heat reclamation would justify the increased investment costs. But would the investment costs per horsepower installed be increased? There would be expenses incurred in making such generation of steam practical. But would these expenses be as great as the cost of furnace, stoker, boiler, smokestack, etc., to generate the same amount of steam? The cost per horsepower of a steam installation including these items is comparable to that of a Diesel plant.

When one considers the advances being made in steam engineering and the complicated means being used to improved economy, and, on the other hand, the fact that little has been done in improving the efficiency of the Diesel engine since the days of Dr. Diesel, it seems that the Diesel is due for improvements in order that it might not lose more of its superiority in heat economy.

Principles and Characteristics o

With the increasing development of new types of motors for all purposes one is likely to lose sight of the fact that all motors can be classified under a relatively small group of fundamental type. These types together with their characteristics are discussed in this article

AN EXAMINATION of the catalogs of electrical manufacturing companies discloses an almost amazing variety and sizes of motors and to one not familiar with the characteristics and methods of classifying motors the task of selecting the right motor for a particular job must appear quite hopeless. All motors, however, can be classified under a relatively small number of groups and when this is done the task becomes much simpler. For example, all motors can be classified according to the type of electric system they are designed to operate from into three groups, direct current, single phase alternating current and polyphase alternating current.

This method of classification is quite general and at best gives little or no information about the motor's performance characteristics. A more convenient classification is one which lists motors as to their speed characteristics. The National Electrical Manufacturers Association for example has adopted the following one, in which all motors are grouped under five classifications:

1. Constant speed motors. Motors whose speed is practically constant from no load to full load. Motors of this class may have an absolutely constant speed regardless of load or the speed may vary a few per cent from no load to full load. This variation in speed of a motor from no load to full load expressed as a percentage of full load speed is called the *speed regulation* of a motor.

2. Adjustable Speed Motors. Motors in which the speed can be varied gradually over a considerable range, but when once adjusted, remains practically constant regardless of the load.

3. Multi-speed Motors. Motors which can be operated at any one of several definite speeds, each being practically independent of the load.

4. Varying Speed Motors. In these motors the speed varies with the load, ordinarily decreasing as the load increases, but for some special applications can be designed so that the speed actually increases as the load increases.

5. Adjustable varying speed motors. Motors in which the speed can be varied over a considerable range but in which the speed when once adjusted to a given load will vary in considerable degree with change in the load.

This method of classification, it is evident, is considerably more informative than the method of grouping according to the type of electric system it is designed for, but still it does not tell the whole story. There are a number of other characteristics which are equally important, all of which will be considered in this discussion.

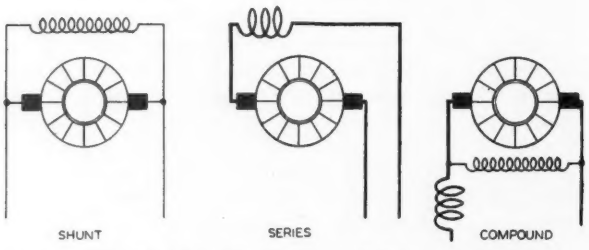


Fig. 1. The three fundamental types of direct current motors

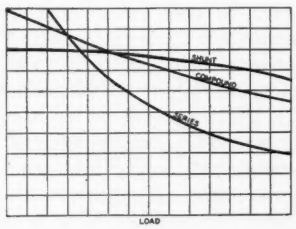


Fig. 2. Speed characteristics of direct current motors

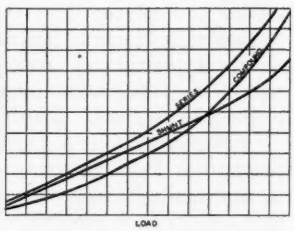
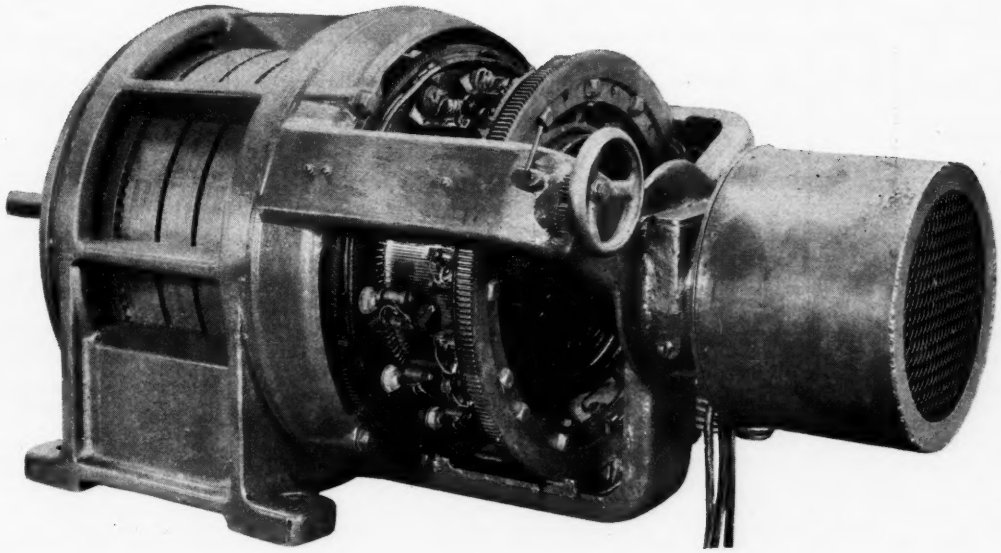


Fig. 3. Torque characteristics of direct current motors

For convenience in comparison, however, we have compiled the full page tabulation which appears on the second page following and lists briefly all the important types of motors together with their respective characteristics.

Electric motors are rated either for continuous duty or intermittent duty. General purpose motors are always rated on a continuous duty basis. Motors of the multi-speed or adjustable speed type may be designed for different types of continuous duty ratings. In the case of a *constant torque motor* which has the same rated torque at all speeds, the rated horsepower is different at different speeds. The highest rated horsepower will be at the highest speed and vice versa. Such

...cs of ELECTRIC MOTORS



motors, therefore, are usually given two ratings, one the maximum allowable horsepower corresponding to the highest speed, and the other, the minimum horsepower which is the maximum allowable horsepower at the lowest speed.

In a multispeed or adjustable speed motor designed for *constant horsepower,* the opposite condition from that just described obtains. Motors of this kind deliver the same horsepower output at all speeds, hence the torque differs for the different speeds, being the smallest for the highest speed.

Another factor of importance governing the application of motors is the torque or turning effort exerted by the motor under various conditions. A motor which is easily capable of pulling a certain load may not be able to start from standstill under that load. For this reason the starting or static torque of the motor is of importance. This is the turning effort exerted by the motor in starting from rest. Certain motors such as the series wound direct current motor have a starting torque equal to 3 and 4 times the full load at normal speed.

In considering the question of momentary overload to which the motor might be subjected, the breakdown or pull out torque is of importance. This is the maximum turning effort that the motor will develop when running without a sudden drop in the speed and consequent stalling of the motor. As shown by the table, this varies anywhere from 125 to 250 per cent or more of full load for various types of motors.

If the starting torque is important so also is the starting current, that is, the current pulled from the line at the instant of starting. This is usually considerably in excess of the normal current taken by the motor and naturally affects the selection of starting equipment and must also be considered in relation to the circuits from which the motor is operated.

Direct Current Motors

The three different types of direct current motors in use are all fundamentally the same in principle and differ only in the manner in which the armature and field circuits are interconnected. These three types are the shunt-wound, the series wound and the compound wound types, shown in Fig. 1. In the shunt wound machine, the field winding consists of a relatively large number of turns of fine wire connected in parallel with the armature. The field current is only a small fraction of the current taken by the armature but because of the large number of turns in the winding, the "ampere-turns" are relatively high.

In the series wound motor, the entire current taken by the motor passes through the field which in this case consists of only a few turns of heavy wire. The compound wound motor is a combination of the first two having both a series and a shunt field.

Since the current through the field of a shunt wound motor is constant, the speed of the motor is practically constant from no load to full load, though it does drop off some as the load is increased. The speed of the series motor, however, drops off rapidly as the load increases, and vice versa. Indeed, if a series motor were operated at no load with normal voltage its speed would rise to the point of destruction.

Since the compound motor is a combination of the series and shunt motors, the speed characteristics are a compromise between those of the shunt and series motors. While the speed drops off as the load in-

Types and Characteristics of Electric Motors

Type of Motor	Service	Starting Duty	Speed	Regulation	Max. Torque—%Full Load	Remarks
Direct Current						
Shunt Wound	Gen. Pur.	Medium—150%	Constant	Close—5-7½%	Limited by commutation	About 25% increase in speed possible by field control. Suitable for steady loads, fans, stokers, lathes, planers, agitators, mixers.
Series Wound	Spec. Ser.	Very Heavy—300-400%	Constant	Wide—depends on load	Limited by commutation	For hoists, cranes, valves, balers, traction. Must be geared to load.
Compound Wound	Spec. Ser.	Heavy—175-200%	Constant	Wide—10-25%	Limited by commutation	For flywheel loads and other widely fluctuating loads which occur less than 25 times per minute. For compressors, conveyors, crushers.
Polyphase Alternating Current						
Squirrel Cage						
Normal torque, normal starting current	Gen. Pur.	Medium—150%	Constant	Close—3-6%	175—200%	The simplest and most widely used motors made. For fans, lathes, grinders, stokers, agitators, pumps, mixers.
Normal torque, low starting current	Gen. Pur.	Medium—100-150%	Constant	Close—3-6%	200%	Designed to start on full voltage. For fans, blowers, centrifugal pumps, planers, lathes, stokers.
High torque, low starting current	Spec. Ser.	Heavy but at not too frequent intervals 175-275%	Constant	Close—4-6%	175—200%	Across the line starting. Especially applicable to pumps, compressors, conveyors, crushers, pulverizers.
Low torque, low starting current	Spec. Ser.	Low—50-60%	Constant	Close—4-6%	125—150%	For special service, constant load. For fans, centrifugal pumps, crushers, motor generator sets. Simple control.
High resistance rotor	Spec. Ser.	Heavy—175-200%	Constant	Wide—10-15%	175-200%	For intermittent special service duty. For elevators, cranes, conveyors, valves, balers, car pullers.
High Slip, Sq. Cage	Spec. Ser.	Heavy—200-250%	Constant	Wide—8-12%	175-250%	Especially desirable for use with flywheels to care for high peak loads which occur less than 25 times per min. Laundry washers, power hammers, punches, shears.
Multi Speed						
Variable torque	Spec. Ser.	Medium—150%	Adjustable	Close—4-6% for each speed	175—200%	Full load rated torque varies directly with speed. Speed independent of load. For fans.
Constant torque	Spec. Ser.	Medium—150%	Adjustable	Close—4-6%	175—200%	Allowable rating varies directly with speed. Speed independent of load. For blowers, pumps, elevators, cranes, conveyors, stokers, pulverizers.
Constant H.P.	Spec. Ser.	Medium—150%	Adjustable	Close—4-6%	175—200%	Same rated hp. for all speeds. For machine tools.
Wound Rotor	Spec. Ser.	Heavy—200-250%	Constant or Adjustable	Wide—depends on load	175-250%	Used with proper type of control where frequent and heavy starting is required or where low starting current is imperative or where varying speed is desired. For compressors, pumps (displacement), cranes, conveyors, crushers, pulverizers.
Commutator, brush shifting	Spec. Ser.	Heavy—150-200%	Variable	Wide—10-30%	150-200%	High first cost. Excellent speed control. For fans, compressors, pumps.
Synchronous						
Standard	Gen. Pur.	Medium—80-125%	Constant	None	175-250%	May be applied, 1. Where maximum possible operating efficiency is desired for steady continuous loads of 75 hp. and larger. 2. Where exact speeds must be obtained. 3. Where motor speeds of less than 500 r.p.m. are required in sizes 20 hp. and larger. 4. Where power factor improvement is desired. For fans, compressors, pumps, motor generator sets.
Fynn Weichsel Type	Spec. Ser.	Heavy—250%	Constant	None except for short intervals	250%	Starts as a wound rotor induction motor. Runs as synchronous motor. May be operated at speeds below normal for short periods of time. Gives leading power factor, 87-92% at full load and 40-60% at no load. Can be used as synchronous condenser. Self excited.
Single Phase, Alternating Current						
Repulsion ind.	Gen. Pur.	Very Heavy—225-300%	Constant	Close—4-6%	150-175%	Low starting current, high starting torque. These motors start as repulsion motors and when up to speed a centrifugal device short circuits the commutator segments making it an induction motor. For fans, blowers, compressors, pumps, conveyors, stokers—a good general purpose motor.
Split phase ind.	Gen. Pur.	Heavy—150-200%	Constant	Close—5-7½%	150-175%	Infrequent start. Steady loads. Made only in the fractional horsepower sizes up to ½ hp. For fans, compressors, pumps, stokers.
Capacitor ind.	Gen. Pur.	Medium—150%	Constant	Close—4-5%	125-150%	Quiet operating. High power factor. There is also available a high starting torque type, which will develop from 200 to 350 per cent of their rated torque at starting. For fans, blowers, compressors, pumps, machine tools, conveyors, stokers.
Repulsion	Spec. Ser.	Heavy—250-300%	Variable	Wide—depends on load	.....	For loads involving heavy starting torque sudden overloads, printing presses, fans and blowers.
Series	Gen. Pur.	Very Heavy	.....	Wide—depends on load	Limited by commutation	Finds its widest application in fractional horsepower services for fans, appliances and small drills.

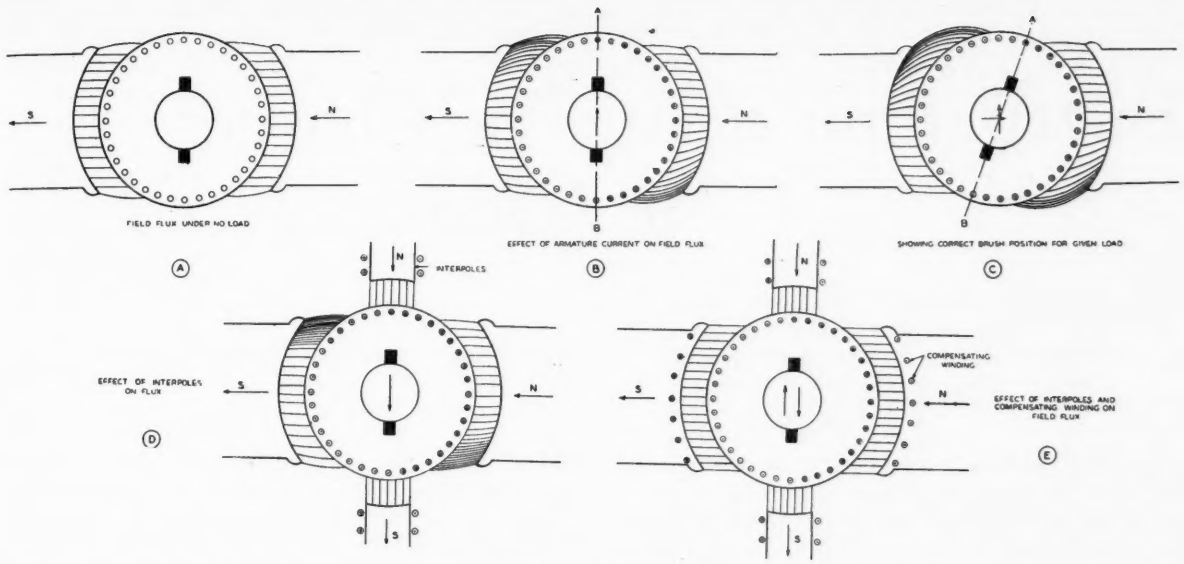

FIELD FLUX UNDER NO LOAD
EFFECT OF ARMATURE CURRENT ON FIELD FLUX
SHOWING CORRECT BRUSH POSITION FOR GIVEN LOAD
INTERPOLES
EFFECT OF INTERPOLES ON FLUX
COMPENSATING WINDING
EFFECT OF INTERPOLES AND COMPENSATING WINDING ON FIELD FLUX

Fig. 4. Diagrams showing effect of armature reaction and how it is corrected by the use of interpoles and compensating winding

creases, the drop is considerably less than that of the series motor. The relative speed characteristics of the three types of direct current motors are shown in Fig. 2. The corresponding torque characteristics of these motors are shown in Fig. 3.

In all these motors, the fundamental principle of operation involves the interaction of two magnetic fields. In practice, however, a number of factors enter to complicate the simple principles upon which the motor action depends. Among the most important of these is "armature reaction," or the distortion of the field flux due to the magnetic field of the armature current. This results in a displacement of the field flux and a consequent shift in the plane of commutation. Thus the correct brush position for one load will not be correct for another load.

Shifting of brushes to accommodate the motor to change in load is unsatisfactory, however, and the difficulty can be overcome in a far better way by the use of interpoles. These are small magnetic poles mounted between the main poles and their windings connected usually in series with the armature. Their purpose is to set up a field which tends to neutralize the effect of armature reaction.

Interpoles alone, however, do not entirely counteract the effects of armature reaction. Their influence is restricted to a narrow zone under its pole tip. At high speeds even with interpoles the armature reaction tends to cause a non-uniform distribution of flux in the main pole pieces. It tends to crowd the flux into one side of the pole tips, causing an unequal distribution of voltage in the various coils of the armature between any two brushes with a consequent tendency toward "flashing" across the commutator. In practice, it is possible to compensate for this action by introducing still another winding in slots across the face of the main field poles. This is known as a compensating or distributed winding. It is connected in series with the armature and its field opposes the cross magnetizing influence of the armature.

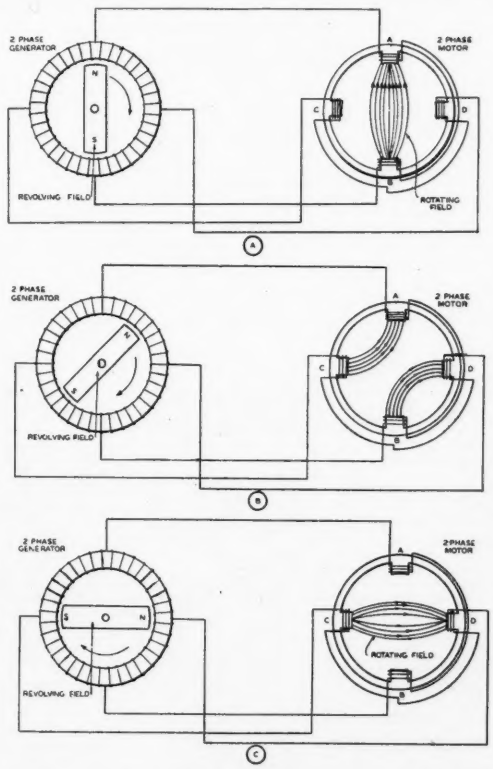


Fig. 5. Diagrams showing principle of operation of the polyphase induction motor

Polyphase Alternating Current Motors

Polyphase alternating current motors and also single phase alternating current motors may be classified into two main groups, induction motors and synchronous motors. Induction motors differ from other types of motors in that there is no electrical connection between the winding on the rotating element and any source of electrical supply. The current

Continued on p. 536

Distribution *of* Energy Charges *in Industrial Plants*

Part II.* Specific Conditions Under Which the Convertible Energy Balance Method of Distributing Energy Charges Should Be Used

By Linn Helander

QUITE a contrast in conditions exists between non-condensing and condensing power generation, so much difference is there that a cost system which may be equitable in the case of non-condensing plants is entirely unsuited to the condensing plant. This was pointed out in Part I of this series which appeared in the October issue where specific cases of non-condensing conditions were analyzed. Cases where condensing conditions exist will be considered here.

CASE II

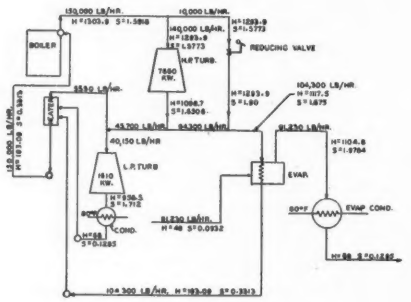
Case II is that of a plant in which by-product power is generated by a low pressure condensing turbine which supplies steam to an evaporator, and non-by-product power by a low pressure condensing turbine which obtains steam from the exhaust line of the non-condensing turbine. Boiler steam is delivered to this line through a reducing valve.

The heat balance distribution of charges in Case II leads to a charge of 3600 B.t.u. per kw-hr. against power generated by the high pressure non-condensing element, 25,900 B.t.u. per kw-hr. against power generated by the low pressure condensing element, and 7460 B.t.u. per kw-hr. against the combined amount of power generated by the two elements. The available-energy-balance distribution of charges, on the other hand, gives a charge of 11,550 B.t.u. per kw-hr. against power generated by the high pressure element; 13,950 B.t.u. per kw-hr. against the power generated

*Part I published on page 450 of the October 1934 issue of Power Plant Engineering.

Case II. Condensing power generation

With bleeder connection for process steam. For this case the convertible energy balance should be used as the basis for distributing energy charges.



Heat Balance and Available Energy Balance

Item	Heat Consumed B.t.u./Hr.	Heat Consumed Per Cent of Total	Avail. Energy Consumed B.t.u./Hr.	Avail. Energy Consumed Kw.	Avail. Energy Consumed Per cent of Total	Charge
1. Radiation in header	1,500,000	0.9	1,136,000	332	1.74	General
2. H.P. Turbine	27,380,000	16.4	58,870,000	9630	90.33	Power
3. Reducing Valve	Zero	Zero	1,743,000	510	2.66	General
4. Header to evaporator	Zero	Zero	27,000	8	.04	General
5. Evaporator	Zero	Zero	17,195,000	5040	26.35	Evap.
6. Evap. condenser	94,580,000	56.7	3,500,000	1023	5.35	Evap.
7. Evap. cond. condensate	1,825,000	1.2	36,000	11	.05	Evap.
8. L.P. turbine	2,709,000	3.4	7,041,000	2060	10.76	Power
9. L.P. turb. condenser	33,675,000	21.4	1,343,000	396	2.06	Power
10. Feed heater	Zero	Zero	421,000	123	.64	General
11. Total	166,621,000	100.0	65,331,000	19,134	100.00	

Recapitulation of Heat Charges

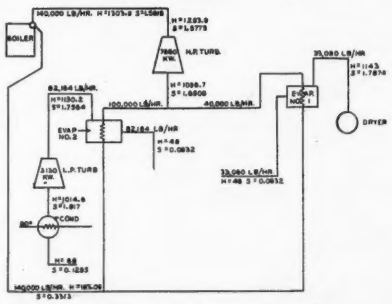
Item	Distribution of Heat Charges		Unit Charges Against Power		Unit Charges for Process Heat	
	Based on Heat Balance Per cent of Total	Based on Avail. Energy Balance, Per-cent of Total	Based on Heat Balance B.t.u. per Kw-hr.	Based on Avail. Energy Balance B.t.u. per Kw-hr.	Based on Heat Balance B.t.u./B.t.u.	Based on Avail. Energy Balance B.t.u./B.t.u.
1. Evaporator	58.4	33.4	-	-	1.01	.397
2. Power	41.6	66.6	7460	11,960	-	-

Segregated Charges Against Turbines

Item	Distribution of Heat Charges		Unit Charges Against Power	
	Based on Heat Balance Per cent of Total	Based on Avail. Energy Balance, Per-cent of Total	Based on Heat Balance B.t.u. per Kw-hr.	Based on Avail. Energy Balance B.t.u. per Kw-hr.
1. H.P.Turbine	16.6	53.1	3,600	11,550
2. L.P.Turbine & Condenser	25.0	13.3	25,900	13,950
Total	41.6	66.6	-	-

Case III. Condensing power generation

With bleeder connection for process steam, arranged specifically to show conditions under which the heat balance method of distributing charges is not applicable.



Heat Balance and Available Energy Balance

Item	Heat Consumed B.t.u./Hr.	Heat Consumed Per cent of Total	Avail. Energy Consumed B.t.u./Hr.	Avail. Energy Consumed Kw.	Avail. Energy Consumed Per cent of Total	Charge
1. Radiation in header	1,400,000	0.9	1,060,000	311	1.74	General
2. H.P. Turbine	27,380,000	17.6	53,074,000	9630	53.90	Power, H.P.T.
3. Evap. No. 1	Zero	Zero	1,767,000	517	2.90	Evap. No. 1
4. Dryer	36,224,000	23.3	5,950,000	1743	9.77	Dryer
5. Evap. No. 2	Zero	Zero	2,861,000	847	4.19	Evap. No. 2
6. L.P. Turbine	11,120,000	7.14	13,812,000	4050	22.65	Power, L.P.T.
7. Condenser	77,793,000	50.00	2,921,000	856	4.80	Power, L.P.T.
8. Condensate from condenser	1,643,000	1.06	33,000	10	.06	Power, L.P.T.
Total	155,513,000	100.00	60,976,000	17,864	100.00	

Recapitulation of Heat Charges

Item	Distribution of Heat Charges		Unit Charges Against Power		Unit Charges for Process Heat	
	Based on Heat Balance Per cent of Total	Based on Avail. Energy Balance, Per-cent of Total	Based on Heat Balance B.t.u. per Kw-hr.	Based on Avail. Energy Balance B.t.u. per Kw-hr.	Based on Heat Balance B.t.u./B.t.u.	Based on Avail. Energy Balance B.t.u./B.t.u.
1. Evap. No. 1	Zero	2.85	-	-	-	-
2. Evap. No. 2	Zero	4.58	-	-	-	-
3. Dryer	23.50	9.95	-	-	1.01	.427
4. Power	76.50	82.64	11,000	11,950	-	-

Segregated Charges Against Turbines

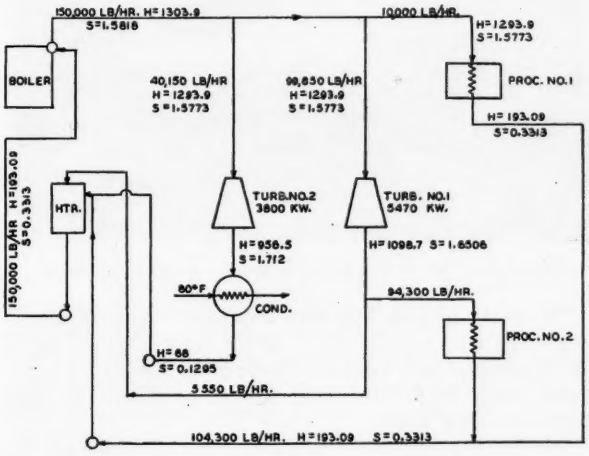
Item	Distribution of Heat Charges		Unit Charges Against Power	
	Based on Heat Balance Per cent of Total	Based on Avail. Energy Balance, Per cent of Total	Based on Heat Balance B.t.u. per Kw-hr.	Based on Avail. Energy Balance B.t.u. per Kw-hr.
1. H.P.Turbine	17.8	54.84	3,600	11,120
2. L.P.Turbine & Condenser	59.7	28.00	29,500	13,950

by the low pressure element, and 11,950 B.t.u. per kw-hr. against the combined amount of power generated by the two elements.

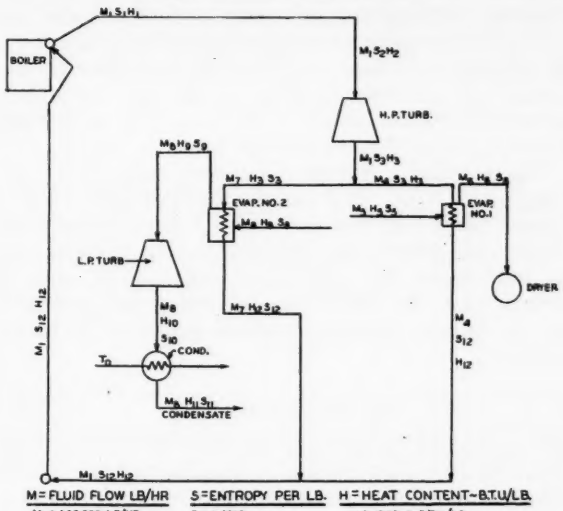
The charge for heat consumed by the industrial processes is 58.4 per cent of the total amount of heat consumed, when the heat balance is used as the basis for distributing energy charges, and 33.4 per cent of the total when the available energy balance is used for the distribution of energy charges. The available energy balance method of distributing charges, if used for this case, will promote a desirable extension of industrial processes using low pressure bled or exhaust steam, since this method of distributing charges makes a low charge for heat furnished by such steam. The available energy balance method also shows clearly the loss occurring at the reducing valve, and it avoids the absurdity of making an excessively small charge for power generated by the high pressure element and an excessively high charge for power generated by the low pressure element. The heat balance method of distributing charges in this case has little to recommend it.

Case IV. Condensing power generation

With plant equipment arranged to show that convertible energy balance method of distributing energy charges offers an incentive, lacking when the heat balance method is used, to replace high pressure process steam by low pressure process steam wherever practicable.



Sample calculations for Case III



M = FLUID FLOW LB/HR	S = ENTROPY PER LB.	H = HEAT CONTENT - B.T.U/LB.
M_1 = 140,000 LB/HR.	S_1 = 1.5818	H_1 = 1303.9 B.T.U/LB.
M_4 = 40,000 LB/HR.	S_2 = 1.5773	H_2 = 1293.9 B.T.U/LB.
M_5 = 33,080 LB/HR.	S_3 = 1.6506	H_3 = 1098.7 B.T.U/LB.
M_7 = 100,000 LB/HR.	S_3 = 0.0932	H_3 = 48 B.T.U/LB.
M_8 = 82,164 LB/HR	S_6 = 1.7874	H_6 = 1143 B.T.U/LB.
	S_8 = 0.0932	H_8 = 48 B.T.U/LB.
	S_9 = 1.7584	H_9 = 1150.2 B.T.U/LB.
	S_{10} = 1.817	H_{10} = 1014.8 B.T.U/LB.
	S_{11} = 0.1295	H_{11} = 68 B.T.U/LB.
T_0 = 340 DEG. F. ABS.	S_{12} = 0.3313	H_{12} = 193.09 B.T.U/LB.

Case III

Case III is similar to Case II, except that the process equipment has been rearranged and modified in order to show more clearly some of the absurdities to which the heat balance method of distributing energy charges leads when this method is inapplicable.

The heat balance method, in this case, makes no charge against evaporators 1 and 2, a small charge per kw-hr. against the high pressure turbine, a heavy charge per kw-hr. against the low pressure turbine, and a heavy charge against the dryer. The available energy balance method of distributing charges, on the other hand, makes equitable charges among these elements.

Case IV

Case IV has been arranged to show specifically how the available energy balance method of distributing energy charges places a premium on high

Heat and Available Energy Balances

Item	Heat Consumed B.t.u./Hr.	Heat Consumed Per cent of Total	Avail. Energy Consumed B.t.u./Hr.	Avail. Energy Consumed Kw.	Avail.Energy Consumed Per cent of Total	Charge
1. Radiation in header	1,500,000	0.9	1,135,000	333	1.74	General
2. Turbine No. 1	19,492,000	11.7	23,448,000	6880	35.90	Turb. No. 1
3. Turbine No. 2	13,547,000	8.1	16,465,000	4820	25.20	Turb. No. 2
4. Condenser	35,675,000	21.4	1,365,000	400	2.08	Turb. No. 2
5. Feed Heater	Zero	Zero	421,000	123	.64	General
6. Process No. 1	11,008,000	6.6	4,280,000	1250	6.56	Proc. No. 1
7. Process No. 2	85,401,000	51.3	18,217,000	5340	27.88	Proc. No. 2
8. Total	166,621,000	100.0	65,331,000	19,146	100.00	

Recapitulation of Heat Charges

Item	Distribution of Heat Charges		Unit Charges Against Power		Unit Charges for Process Heat		Unit Charges for Process Steam	
	Based on Heat Balance Per cent of Total	Based on Avail. Energy Balance, Per-cent of Total	Based on Heat Balance B.t.u. per Kw-hr.	Based on Avail. Energy Balance B.t.u. per Kw-hr.	Based on Heat Balance B.t.u./B.t.u.	Based on Avail. Energy Balance B.t.u./B.t.u.	Based on Heat Balance B.t.u./lb.	Based on Avail. Energy Balance B.t.u./lb.
1. Process No. 1	6.65	6.70	-	-	1.01	1.01	1110	1110
2. Process No. 2	51.80	28.60	-	-	1.01	.557	915	505
3. Turb. No. 1 & Cond.	11.80	36.70	3,600	11,180	-	-	-	-
4. Turb. No. 2 & Cond.	29.75	28.00	13,050	12,260	-	-	-	-

pressure steam and thus discourages its use for processes, whereas the heat balance method makes no distinction between high and low pressure steam, except for differences in heat content, and thus offers to the operator no inducement to encourage him to employ low pressure steam, where it can be used for industrial processes, in preference to high pressure steam.

The available energy balance distribution of charges in Case IV makes approximately equal charges per kw-hr. against power generated by each of the two generating elements and distributes the charges among the industrial processes in such a manner that the advantage of using low pressure bled or exhaust steam for these processes is made obvious.

Heat balance calculations

Disposition of Heat	Formula	Calculations	Result B.t.u./Hr
1. Loss in header	$M_1(H_1 - H_2)$	140,000 (1303.9-1293.9)	1,400,000
2. H.P. turbine	$M_1(H_2 - H_3)$	140,000 (1293.9-1098.7)	27,328,000
3. Evap. No. 1	$M_4H_4+M_5H_5-M_6H_6-M_7H_{12}$	40,000x1098.7+33,080x48-35,080 x1143-40,000x193.09	Zero
4. Dryer	$M_5(H_4 - H_5)$	33,080 (1143-48)	36,224,000
5. Evap. No. 2	$M_3H_3+M_6H_6-M_8H_8-M_9H_{12}$	100,000x1098.7+82,164x48-82,164x1150.2-100,000x193.09	Zero
6. L.P. turbine	$M_8(H_8 - H_{10})$	82,164 (1150.2-1014.8)	11,125,000
7. Condenser	$M_9(H_{10} - H_{11})$	82,164 (1014.8-68)	77,793,000
8. Condensate	$M_9(H_{11} - H_9)$	82,164 (68-48)	1,643,000

Available Energy Balance Calculations

Disposition of Available Energy	Formula	Calculations	Result B.t.u./Hr.
1. Loss in header	$M_1[H_1 - H_2 - T^0(S_1 - S_2)]$	140,000 [1303.9-1293.9-540 (1.5818-1.5773)]	1,080,000
2. H.P. turbine	$M_1[H_2 - H_3 - T^0(S_2 - S_3)]$	140,000 [1293.9-1098.7-540 (1.6506-1.5773)]	28,874,000
3. Evap. No. 1	$M_4H_4+M_5H_5-M_6H_6-M_7H_{12}$ $-T^0[M_4S_4+M_5S_5-M_6S_6-M_7S_{12}]$	Zero-540 [40,000x1.6506+33,080x 0.958-33,080x1.7074-40,000x .3313]	1,767,000
4. Dryer	$M_5[H_4 - H_5 - T^0(S_4 - S_5)]$	33,080 [1143-48-540 (1.7074-.0938)]	5,958,000
5. Evap. No. 2	$M_3H_3+M_6H_6-M_8H_8-M_9H_{12}$ $-T^0[M_3S_3+M_6S_6-M_8S_8-M_9S_{12}]$	Zero-540 [100,000x1.6506+82,164x .0938-82,164x1.7564-100,000x.3313]	8,551,000
6. L.P. turbine	$M_8[H_8 - H_{10} - T^0(S_8 - S_{10})]$	82,164 [1150.2-1014.8-540 (1.7564-1.617)]	13,818,000
7. Condenser	$M_9[H_{10} - H_{11} - T^0(S_{10} - S_{11})]$	82,164 [1014.8-68-540 (1.617-.1295)]	* 2,921,000
8. Condensate	$M_9[H_{11} - H_9 - T^0(S_{11} - S_9)]$	82,164 [68-48-540 (.1295-.0938)]	33,000

On the other hand, the heat balance method of distributing charges makes widely unequal charges per kw-hr. against power generated by the two elements and offers no inducement to encourage operators to use low pressure exhaust or bled steam for the industrial processes in place of high pressure steam. Thus the charge against power is 3600 B.t.u. per kw-hr. for that portion generated by the non-condensing turbine and 13,050 B.t.u. per kw-hr. for that portion generated by the condensing turbine, if the heat balance is used for distributing charges.

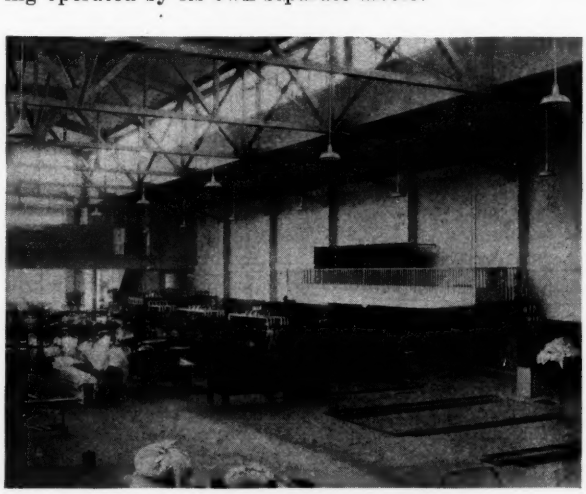
If the available energy balance is used for distributing charges, the charge against power developed by the non-condensing turbine is 11,180 B.t.u. per kw-hr., that against power developed by the condensing turbine 12,260 B.t.u. per kw-hr. When the heat balance is used for distributing charges, the unit charges for heat used by processes numbers 1 and 2 are identical, 1010 B.t.u. per 1000 B.t.u. consumed, although process number 1 uses boiler steam directly while process number 2 uses only exhaust steam from the generating unit. When the available energy balance is used in place of the heat balance, the unit charges for heat used by these processes are 1010 B.t.u. per 1000 B.t.u. of heat consumed and 557 B.t.u. respectively, the lower charge being made against process number two, the one that uses low pressure exhaust steam.

For the sake of simplicity, the energy returned to the feedwater by the feed pump has been ignored in each of the five cases. In the diagrams, H represents heat content or enthalpy per lb.; S represent entropy per lb. Boiler losses have not been included in the energy balances or in the heat charges against power and processes.

Laundry Steam Lines, Underground

AN INTERESTING feature of the Ideal Laundry plant in San Francisco is that all the steam pipes, which are the most conspicuous feature of the average laundry are missing. All of the steam, compressed air and water lines from the power plant to the wash units and the soap, bleach and soda pipes as well, are carried in concrete floor trenches varying from 9 in. wide by 6 in. deep to 2 ft. wide by 15 in. deep. The laundry is thus entirely free from overhead lines.

All the conduits for electrical wiring are laid in the concrete floor slabs and brought up to the proper motor connections on the machines, each machine being operated by its own separate motor.



Steam lines laid in trenches give laundry a neat appearance

In order to give a smooth unbroken trucking floor, combined with ease of access to the pipe lines, the covers of the trenches consist of removable reinforced concrete slabs from 2 to 3 in. thick, as shown in the accompanying photo.

All remote control equipment for the entire plant is installed on an overhead platform or balcony, from where the electrician in charge can see every machine in the plant.

WRITTEN TELEGRAMS are now being transmitted from the sender's typewriter direct to the receiver's printing set, without the aid of an intermediate operator. Connection between stations, as well as operation of the printing set are by series of current impulses similar to those used in the automatic telephone. The message is written on the sender's machine and exactly reproduced on the receiver's set, at the speed of ordinary typewriting. This system has been developed by Siemens-Schuckert and is in use in Germany, the rates being low, so that transmission of 390 words between Berlin and Hamburg costs about the same as a 3-min. telephone connection. A similar machine is adapted for wireless transmission using a 5-point alphabet.

The Diesel Engine *Enters the* Movies

Motion Pictures Taken at 1850 Frames Per Sec. Show Ignition and Combustion Conditions in Engine Cylinders

By E. C. Buckley* and C. D. Waldron*

MANY METHODS have been used to study the combustion process in an internal-combustion engine, including: analysis of indicator cards; observation of the flame by a stroboscope; continuous, or "streak," photography of a narrow band of the flame as shown through a slit; analysis of gas samples taken progressively throughout the cycle by a stroboscopic valve; recording of flame travel by electric devices; and stroboscopic photographing of the spectrum of the gases in the cylinder. Although each of these methods has advantages over the others for studying some particular phase of the combustion process, all of them have definite limitations. When making a photographic investigation of combustion it is desirable to obtain a progressive picture of the combustion as complete as possible, in respect to both time and included field.

In previous work on the effect of fuel vaporization on combustion with the N.A.C.A. combustion apparatus some continuous photographic records of the flame were obtained through 2-in. round windows fitted in the sides of the combustion chamber. These pictures gave the approximate location of the ignition relative to the spray and an idea of the rate of flame spread through the combustion chamber. They showed the flame spread when the progress of the flame was slow and toward the sides of the chamber, giving the speed of flame in only one direction.

This was followed by additional work using the N.A.C.A. combustion apparatus in conjunction with a high-speed motion-picture camera capable of taking pictures at rates up to 2250 frames per second. Motion pictures taken at this rate through 2½-in. diameter glass windows in the combustion chamber give a fairly complete and progressive picture of normal combustion. Under knocking conditions, however, the combustion process is so speeded up that, even with the present camera speed, the flame fills almost the entire chamber in the interval between successive frames.

*Langley Memorial Aeronautical Laboratory, N.A.C.A., Langley Field, Va. (T.N. No. 496, N.A.C.A. 1934)

Description of Apparatus

A sketch of the N.A.C.A. combustion apparatus, as used in these tests, is shown in Fig. 6. In all tests the fuel was injected from the top of the combustion chamber, which is at the right side of all flame pictures shown. A 6-orifice nozzle was used except where otherwise noted. The fuel used in the present tests was Diesel oil and the quantity injected per cycle was

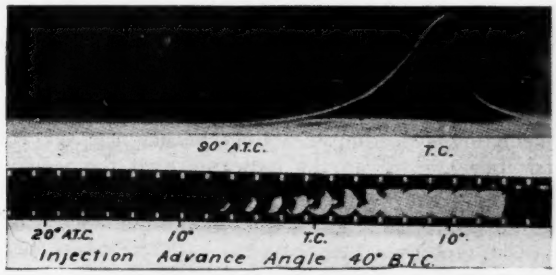
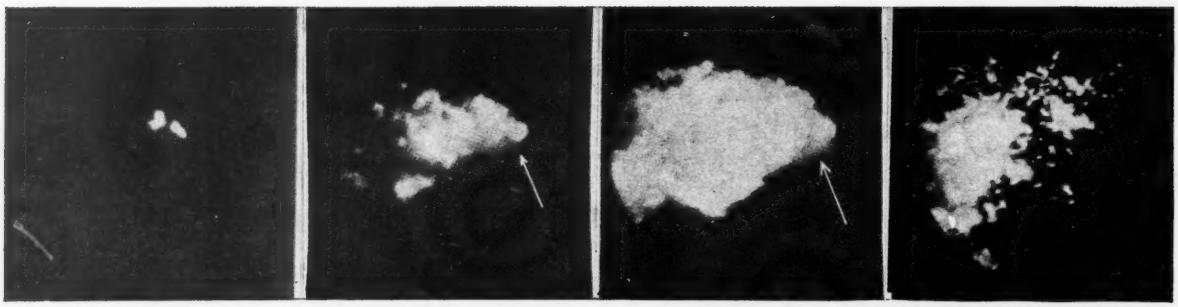


Fig. 1. When the fuel is injected 40 deg. before top center combustion is quickly completed

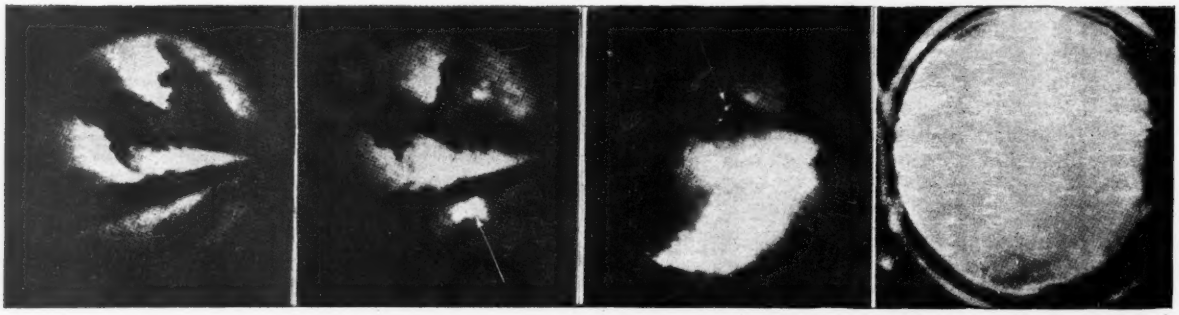
Fig. 2 (Above). When the fuel is injected 20 deg. before top center the combustion period is longer

Fig. 3 (Below). When fuel is injected at top dead center there is still flame at the end of the stroke



First frame Second frame Third frame Twenty-fifth frame

Fig. 4. Flame spread with a single orifice nozzle showing the beginning and end of the flame



Third frame Fourth frame Fifth frame Eighth frame

Fig. 5. Showing the spray, flame beginning and maximum spread with a multiorifice nozzle

0.00025 pound, giving an air factor of about 1.3. The compression ratio was 14.6, the engine speed 570 r.p.m. and the coolant temperature 150 deg. F.

An indicator has been designed to use in conjunction with the engine. This indicator is of the optical type, the deflection of a diaphragm causing a corresponding deflection of a light beam. A spark coil and timer record on the indicator card the phasing with respect to the engine by photographing two sparks that occur 90 crankshaft degrees apart.

The motion-picture camera used in these tests differs from the usual motion-picture camera in that a continuous movement of the film is used instead of the intermittent film usual movement. This continuous movement is made possible by using, in the optical system, a rotating flat prism that causes the image to follow the moving film. With this camera, motion pictures have been taken in some distances at 2250 frames per second. The particular illustrations in this paper were taken at approximately 1850 frames per second; that is, a picture approximately every two crankshaft degrees. The exposure time is one-third of the time interval from picture to picture.

Test Results and Discussion

The first series of pictures with the high-speed motion-picture camera was taken to find the effect of injection advance angle on flame spread. Figures 1 to 3 show indicator cards and motion pictures of the combustion with injection advance angles of 40, 20 and 0 crank degrees before top center.

When the injection advance angle was 40 deg. the ignition lag was greater than the lag obtained with the 0 and 20 deg. advance angles. The first sign of combustion was two small flames that appeared 15 deg. before top center. By 2 deg. later the flames had spread to the edges of the chamber in almost all directions. The indicator card shows that the rate of pressure rise was so rapid that it set the indicator to vibrating; however, this particular explosion was not accompanied by a knock. The card shows that the rate of heat input had decreased decidedly and the flame pictures show that the flame was dying out rapidly at top center. At 10 deg. after top center the flame had died out completely. Since the flame continued in the top of the chamber for some time after it had disappeared in the bottom, the injected fuel evidently did not form a homogeneous mixture with the air even when injected 40 deg. before top center and 25 deg. before ignition started.

The photographs of the flame for the condition in which injection started 20 deg. before top center show that the first flame appeared in the chamber about 12 deg. before top center. The ignition lag was slightly greater than when injection started at top center but the flame spread was more rapid. Again the flame started in more than one place. Only two of these tiny isolated flames appear in the picture taken 12 deg. before top center. Examination of similar records indicates that, as a rule, more of these nuclei of burning appeared before the flames spread through the chamber.

At 10 deg. before top center the flame had spread almost to the edge of the combustion chamber—a slightly greater rate of flame travel than was obtained when injection started at top center. When the third frame was taken the flame had spread to the edge of the chamber in all direcions except one isolated region.

In succeeding pictures this dark region moved around the chamber slightly and, although flame reached all parts of the chamber, it never existed in all parts of the chamber simultaneously. The indicator card shows that the start of pressure rise was gradual and smooth and that maximum pressure occurred in the chamber at top center.

Although the rate of pressure rise was rapid it was not rapid enough to cause knock. The flame pictures show that at top center the flame was beginning to die out in the combustion chamber. Flame continued until 60 deg. after top center. The flame in this afterburning period had a different appearance from the afterburning that occurred when injection started at top center in that, with an injection start of 20 deg. before top center, the late burning appeared to be masses of burning gas instead of more or less isolated nuclei.

The motion pictures of the combustion for the condition in which injection started at top center show that ignition occurred about 5 to 6 deg. after top center and started at several different places near the center of the combustion chamber. The next frame, two crank degrees later, shows that the isolated areas of burning had become connected and the flame had spread through about two-thirds of the combustion chamber. The flame appeared to be intense and had irregular edges which were no doubt caused by the unevenness of the mixture. By the time the third frame was taken the flame had filled the combustion chamber and appeared to be very intense.

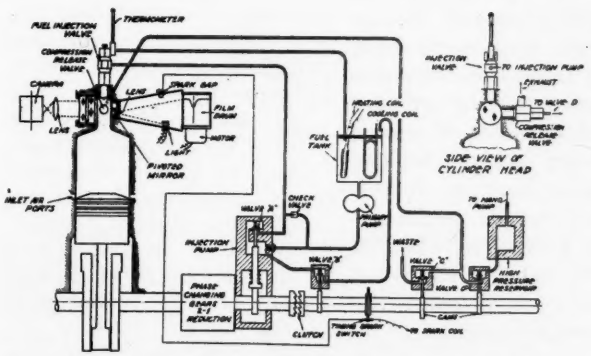


Fig. 6. Diagrammatic sketch of the N.A.C.A. combustion apparatus used in taking moving pictures

The indicator card shows that the maximum pressure was not reached in the combustion chamber until about 13 deg. after top center. Beyond 15 deg. after top center the indicator card shows that the pressure dropped rapidly, indicating that the rate at which heat was liberated by the burning fuel decreased decidedly after this point; however, the flame pictures show that the flame filled the chamber until more than 20 deg. after top center. Beyond 25 deg. after top center the flame steadily became smaller but lasted about 70 deg. longer. At 90 deg. after top center a few tiny isolated flames still existed.

Figure 4 shows some enlargements, to slightly less than full size, of the flame pictures obtained when fuel was injected from a single 0.060-in. nozzle, injection starting at top center. It may be noted that ignition started in the envelope of the spray at more than one position. The second frame shows how the flames had spread and how burning had started in several new isolated areas. In the lower right hand section of the flame the spray can still be seen. The third frame also shows the fuel spray and shows that the flames had spread to the bottom of the windows and about halfway to the side of the combustion chamber. The flame then continued to spread but never completely filled the chamber. It started to die out at the top of the chamber while continuing to burn at the bottom. The last frame shows the small isolated nuclei of incandescence.

Figure 5 shows enlargements of photographs of the spray and the flame, to slightly less than full size, when injection from a multi-orifice nozzle started at top center. Three frames of the film, of which the third is reproduced, show silhouettes of the spray in the chamber. The fourth frame still shows the spray silhouette and also shows the start of the flame in the envelope of one of the sprays. This small flame has a very irregular outline and its brightness varies. The fifth frame shows the flames spread to the edge of the chamber in one direction and to the center of the chamber in the other direction, but still presenting a very uneven appearance. This frame also shows a nucleus of burning in the spray envelope on the opposite side of the chamber. The last picture shows the appearance of the flame at its maximum spread.

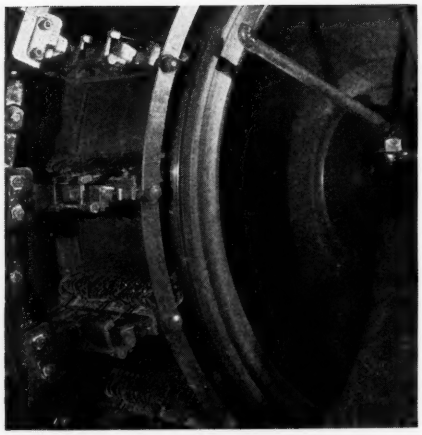
From a study of the high-speed motion pictures presented the following conclusions can be drawn: When ignition occurs during fuel injection in a compression-ignition engine it starts in the spray envelope but when ignition occurs after injection and after considerable mixing has taken place, it is impossible to predict where the start will occur; combustion in a compression-ignition engine usually has many ignition nuclei; with the N.A.C.A. combustion apparatus, as the injection advance angle increases from 0 to 40 crank degrees before top center, the rate of flame spread increases and the duration of burning decreases.

WHEN A new pump was put in operation, it failed to deliver the quantity of water necessary or to the required height. After 10 days of unsuccessful effort by the plant organization, an engineer from the manufacturer arrived. First, he checked the speed of line shaft, which he was told had been done many times, and found it all right. Then came the question of inlet opening, which was controlled by a valve between sludge tank and pump. The valve was reported to be wide open, but the engineer went down to see anyhow and found that he could open it further a full turn of the hand wheel. After that, the pump gave full capacity and head. As in so many cases the cause of the trouble and the remedy were simple. It developed that the plant engineer had never operated a centrifugal pump, so had no idea of the effect that slight change in suction conditions would have on pump operation.

LINK-BELT NEWS.

A Consideration of Brush Phenomena

By R. M. BAKER
Research Engineer,
Westinghouse Elec. & Mfg. Co.



Electrical Sliding Contacts

DESPITE its apparent simplicity, the carbon brush sliding contact is little understood. After using it some 40 years we know little more about the basic phenomena involved than we did when we started. Recent studies of sliding contact phenomena have disclosed more amazing facts, however. For example, it can be shown that in ordinary brush operation current densities of several million amperes per square inch are reached —and this without undue heating. In this article which is presented here by special permission of the Electric Journal in which it first appeared, Mr. R. M. Baker of the Westinghouse Electric & Mfg. Co. discusses this fascinating aspect of brush operation.

IT OFTEN HAPPENS that the things which are most common to us and which we most readily take for granted are the very things we know least about. The carbon brush sliding contact and also the separating contact are excellent examples of this fact. The carbon brush sliding contact appears to be a device of utmost simplicity. Yet after forty years' experience with commutators and collector rings, we know little of the basic phenomena involved.

The ultimate goal of all brush research is to design a contact with the same degree of certainty with which it is today possible to design other parts of electrical machines. That this goal has not been attained is evidenced by the tedious cut-and-try methods that we employ at present to solve brush problems.

This question of Electrical Sliding Contacts is interestingly discussed in an article by R. M. Baker in the September 1934 number of The Electric Journal. Mr. Baker is a research engineer with the Westinghouse Electric and Manufacturing Co. and his discussion brings out a number of startling facts regarding sliding contacts. It is with the special permission of the author and the Electric Journal that we present here the substance of this discussion.

One of the most astonishing things about sliding contacts, it appears, are the high local current densities which exist without excessive heating of the small areas of actual contact. To speak of current densities of a million amperes or more per square inch, offhand, seems absurd and yet such densities occur in sliding contacts. Moreover these amazing conditions exist without undue heating.

The most conspicuous fact in a study of sliding contacts, as pointed out by Mr. Baker, is that the flow of current across such a contact is always associated with a certain voltage drop. This voltage drop is usually spoken of as the contact drop and has generally been accounted for by assuming that the current must flow through some mysterious transition layer. In general, where we have a carbon brush sliding on a copper ring, the current must flow across a layer of oxide having a high specific resistance. This condition naturally results in a loss of voltage. We can, however, construct a contact in which no high resistance oxide film can exist, for instance, a carbon brush sliding on a carbon slip ring. Even in this case we find that the flow of current is associated with a loss of voltage, or, as commonly expressed, there is a contact drop of potential.

In such a contact, the irregularities of the one surface meet those of the opposite contacting surface only at relatively few small areas of actual contact and it is the converging of the current to these small areas that results in the appearance of a contact drop of potential. The small areas at which the two contact members are actually in contact and through which the current must flow have in the ordinary sliding contact a radius of not

more than 10^{-4} to 10^{-3} inches. As the number of such areas is not more than 50 to 100 in a contact area one inch square, the local current density at these areas must reach a value of several million amperes per square inch. The value of contact drop and the temperature of the points of contact can be calculated from the thermal and electrical conductivities of the contact material.

The volt-ampere characteristic of a graphite brush sliding on a graphite ring is shown in Fig. 1. Such a contact illustrated the most simple example of a sliding contact, that is, one containing no oxide film. This contact exhibits a linear volt-ampere characteristic of the carbon brush on a copper ring. In other words, the carbon-carbon contact has a constant resistance independent of current for a very large range of currents, whereas the resistance of the carbon-copper contact decreases very rapidly as the current increases and gives over the same range of currents almost a constant voltage drop. The unusual behavior of the carbon-copper contact is due to the influence of the thin oxide film (10^{-6}—10^{-5} inches thick) on the ring.

To obtain a concrete idea of the magnitude of the quantities in sliding contacts, consider the characteristic of the carbon-carbon contact of Fig. 1. The contact drop with the brush positive is essentially the same as with the brush negative, so that for a single contact here is a resistance of 0.0103 ohm. If such a contact contains N contact areas of radius a and the members of the contact have the resistivities p_1 and p_2 respectively the resistance of the contact is represented by the equation

$$R = \frac{p_1 + p_2}{4aN} \text{ ohms} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

For the contact under consideration

$p_1 = 0.0003$ ohm $\times$ inches (brush)
$p_2 = 0.0012$ ohm $\times$ inches (ring)

so that we find

$aN = 0.0364$

If $N = 50$,

$a = 0.00073$ inch.

If the contact is carrying a current of 50 amp., each small area will carry a current of one ampere or a current density of 0.598×10^6 amp. per sq. in. If the number of contact areas, instead of being 50, is 100, the current density at the points of contact will be 2.39×10^6 amp. per sq. in.; but since the temperature rise at the points of contact depends only upon the voltage drop across the contact and the thermal and electrical conductivities of the contact members, it will be the same in either case.

In calculating the maximum temperature occurring in this contact we observe that 80 per cent of the heat will be generated in the higher resistance ring material and the point of maximum temperature will lie not in the common surface of contact but somewhere just inside the material of the ring. Little error will be made in calculating this temperature if we use the formula

$$t = \tfrac{1}{8} \times \frac{V^2}{Kp} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where

t = maximum temperature rise above the average ring temperature
V = voltage drop in the ring
K = thermal conductivity of the ring material
p = electrical resistivity of the ring material

For our case,

p = 0.0012 ohm $\times$ inches
K = 0.8 watt $\times$ in.$^{-1}$ $\times$ degrees C^{-1}
V = 0.407 volt.

Using these data, we calculate

t = 21.6° C.

This figure for the maximum temperature rise is especially interesting. It is difficult at first to conceive how a material can carry a current density of a million amperes per square inch without becoming excessively hot. The explanation lies in the smallness of the current-carrying area, which allows the heat generated to be carried away very rapidly. The figure of temperature rise is also interesting in the light it throws on conditions in a carbon-brush contact on a copper ring. The voltage drop in the brush itself in this case is rarely greater than that observed in the case just studied, and we must therefore conclude that the heating due to the concentration of current in the brush itself can contribute little to the local heating of the contact. It is assumed in eq. (2) that a contact area is in use long

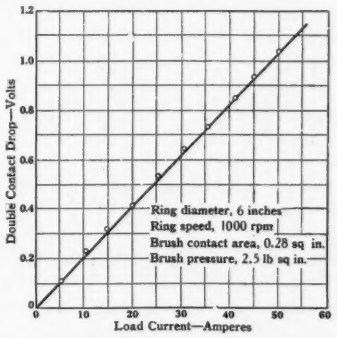


Fig. 1. This curve represents the volt-ampere characteristics of a graphite brush on a graphite ring

enough at one time for steady-state conditions to be reached. It is doubtful if that was true for the contact studied, and the maximum temperature was very probably not so great as calculated. (According to theoretically deduced formulas by Dr. Hohn we would expect the small areas in this contact to require about 3×10^{-4} sec. to reach 90 per cent of their steady-state temperature rise.)

Perhaps the possibility of carrying very high current densities in small areas will seem more plausible to an engineer if we consider the more familiar case of current flowing in a straight wire. Let us assume that the unit heat dissipation from the surface of a wire remains the same as the diameter of the wire is decreased. (In certain cases the unit heat dissipation actually increases as the diameter of the wire is decreased.) Under this condition the heat lost from one inch length of the surface of a wire of radius r is,

$H_1 = K \times 2\pi r$.

The heat generated per inch length is

$$H_2 = \frac{p}{\pi r^2} I_D \times \pi r^2 = p \pi r^2 I_D^2$$

where

I_D = current density in the wire

At the temperature for which K is the watt loss per square inch of wire surface, H_1 must be equal to H_2, that is, the heat generated must be equal to the heat dissipated. Equating the two we find:

$$I_D = \frac{2K}{pr} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Thus we see that as the wire diameter is decreased, the current density in the wire for the same temperature rise can be continually increased. If we can carry a current density of 10,000 amp. per sq. in. in a wire 1000 mils in diameter, we can carry a current density of 1,000,000 amp. per sq. in. in a wire one mil in diameter.

A similar analysis for the case of a small contact area shows that the allowable current density for a given temperature rise is inversely proportional to the first power of the radius a of the small contact area, and therefore increases much more rapidly with decreasing radius than it does for the straight wire.

Thus we understand why it is possible to carry densities of millions of amperes per square inch in a small contact area whereas a one-inch carbon rod, without extreme cooling facilities, will not carry more than a few hundred amperes per square inch without becoming excessively hot.

Qualifying Operators of Welding Equipment

SPEAKING at the Fall meeting of the American Welding Society, E. D. Debes of the Bethlehem Shipbuilding Corp. described the methods his company employs in training men to use welding equipment in the fabrication of steel. Fluctuations in labor and a rather sudden demand for efficient welders made it imperative that methods of training be employed whereby workmen could be developed into reliable operators in the shortest possible time. The essential features of the course as outlined by Mr. Debes are included in the following paragraphs.

In the Summer and Fall of 1933 the number of operators was gradually increased by hiring men who had sufficient experience to pass the Navy Department's qualification tests. Some of these men had worked in shipyards but generally had experience with bare electrodes only, so they had to go through a short period of training with covered electrodes, which are now used exclusively, to enable them to pass the Navy Department tests. Some men without shipyard experience have been hired, but as a rule these men have little experience on overhead and vertical welding and have to go through a period of training before being able to pass the tests.

The Navy Department tests for operators requires satisfactory welds to be made in all three positions under conditions simulating as nearly as possible actual working conditions.

At the first of the year it was decided to open up the welding school and a space in the steel fabrication shop was set aside for this purpose. All necessary equipment to take care of 30 pupils has been installed.

The school is conducted by the foreman of the welding department.

In accepting applicants preference is given to men who have shipyard experience in other trades and especially to men who are working in the plant or have worked in the plant before.

As a preliminary stage, before entering the school, the applicant is required to spend some time after working hours doing welding, under supervision until he demonstrates some manual talent toward the trade. This gives some assurance that an applicant starting in the school will successfully complete the course and the fact that he is willing to sacrifice his own time indicates his seriousness and eliminates curiosity seekers. It has been found that younger men generally acquire the "knack" of welding more rapidly than the older men.

Upon entering the school the pupil receives a small compensation for every hour worked. A complete set of tools is provided and the pupil is turned over to the instructor who is an experienced welder and a man who has the "knack" of teaching.

The course is carried out in accordance with a "Welding Manual" developed by the plant and which contains the following chapters.

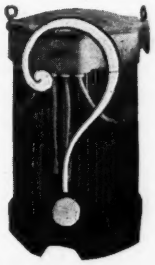
1. Metallic Arc Welding, Fundamentals.
2. General Safety Precautions.
3. How to Run a Bead.
4. Handling the Arc.
5. Placing the Arc Accurately.
6. Filling Craters Smoothly.
7. Tee Joint, Flat.
8. Lap Joint, Flat.
9. Vee Butt, Flat.
10. Single Vee Butt, Flat.
11. Running Bead on Inclined Surface.
12. Running Bead on Vertical Surface.
13. Tee Joint, Vertical.
14. Vee Butt, Vertical.
15. Laying a Bead Overhead.
16. Tee Joint Overhead.
17. Single Vee Butt Overhead.
18. Horizontal Lap Joint.
19. Vertical Lap Joint.
20. Overhead Lap Joint.
21. Filling Holes.
22. Thin Plates, Flat.
23. Thin Plates, Vertical and Overhead.

The specimens, welded by the student, are examined by the instructor and broken in the presence of the student. The instructor then points out whatever defects are apparent and instructs the pupil how to avoid such defects.

When in the opinion of the instructor the work of the pupil is satisfactory a standard test specimen is welded by the student in the presence of a Navy Department inspector. These specimens are machined and tested in accordance with the Navy requirements.

About 200 hr. of training are required to develop an operator sufficiently to pass the qualification tests.

What Is Transformer Polarity



By M. D. Simmons

ALTERNATING CURRENT TRANSFORMER polarity applies to the relative direction of the impressed and induced voltages in the primary and secondary windings and the direction is due to the relative location of the windings. Two common terms applied to polarity are subtractive and additive. The former or subtractive polarity may be defined as the condition which arises when both primary and secondary are wound on the core in the same direction; also when adjacent primary and secondary leads are positive or negative at the same instant. A transformer is said to be of additive polarity when an adjacent primary and secondary terminal is of unlike polarity, that is, when one is positive and the other negative and vice versa; also, when the high and low voltage windings are wound in reverse directions.

These conditions are depicted clearly by referring to Fig. 1 and 2. In Fig. 1 the primary winding is shown by a light line, H1, H2 wound around a core, and the secondary winding by a heavy line, X1, X2. It will be noted that the windings are wound in the same direction; therefore the polarity at H1 will be positive with respect to X1, and is known as subtractive polarity. If the windings are reversed as shown in Fig. 2, H1 and H2 are positive at the same instant that X1 and X2 are, for if the high voltage winding is followed through from H1 to H2 and then the low voltage winding from X2 to X1, it will be found that one complete cycle has been made without changing direction. The transformer which has its windings installed in this fashion is known as a transformer of additive polarity. Fig. 1 and 2 are used only for illustration and do not refer to the actual transformer which has its primary and secondary winding terminals brought out on opposite sides of the transformer.

Terminal markings of H1, H2, etc., and X1, X2, etc., are definite symbols applied to light and power transformers. They were made the American Standard during 1925 by the National Electric Manufacturers' Association in co-operation with the National Electric Light Association, The American Institute of Electrical Engineers, the United States Bureau of Standards, and several other associations in the United States. The primary terminal H1 is fixed as the right hand lead when facing the high voltage side of the transformer. If there are more than two leads from the primary side, they are marked H1, H2, H3, H4, etc., reading from right to left. The secondary lead X1 may be either on the left or right hand side of the transformer when facing the secondary side, depending upon whether the transformer is of additive or subtractive polarity. X1 is found on the left hand side when the transformer is of subtractive polarity and on the right hand side when additive. If subtractive X1, X2, X3, X4, etc., read left to right, and vice versa (X4, X3, X2, X1), if additive.

This data is of interest as manufacturers use these markings. Transformers are constructed with different polarities, that is, some additive and some subtractive. How simple it is to connect three transformers for a power load and still obtain the desired polarity, merely by referring to terminal markings. (Fig. 3 and 4.)

However, transformers may be in stock which do not have the polarity markings; if so, the relative

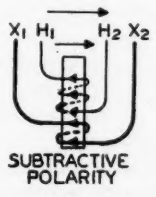


FIG. 1

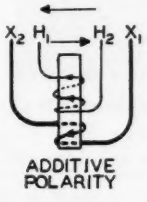


FIG. 2

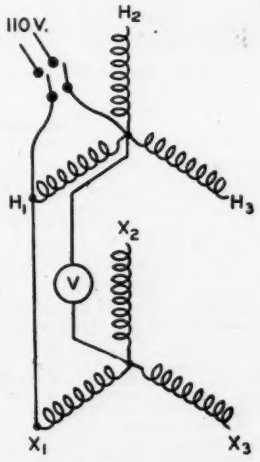


FIG. 6

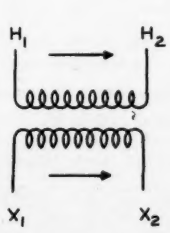


FIG. 3

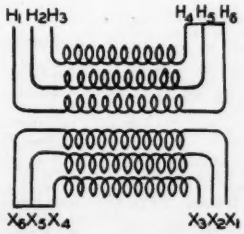


FIG. 4

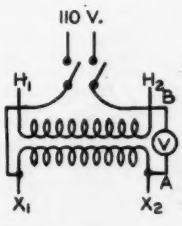


FIG. 5

Fig. 1-6. Diagrams Showing Different Polarity Connections and Method of Testing for Correct Polarity

polarity may be determined by test and tags attached. This is accomplished on a single phase transformer by connecting one high and low voltage lead together as shown in Fig. 5. Impress 110 v. across the high voltage terminals H1 and H2, and take a voltage reading from A to B; if the reading is higher than 110 v., the transformer is additive, and if less, it is subtractive. In the case of a three phase transformer similar readings are taken on one phase from primary to secondary. The connection is made, and reading taken as shown in Fig. 6. A reading taken on one phase will generally indicate the polarity of the other two windings, but if it is desired to check the other phases, it may be done in the manner indicated.

Distribution transformers are known as transformers of 500 kv-a. and less, and are generally of additive polarity while power transformers are in excess of 500 kv-a. and are usually of subtractive polarity. However, manufacturers will supply transformers of all sizes with either polarity as requested.

New Power Plant for Lillybrook Coal Co.

Two stoker fired boilers and two engines cut power costs

DESIRING to reduce their power costs, the Lillybrook Coal Co. of Lillybrook, W. Va., recently completed a new power plant which includes two 5070 sq. ft. type H Sterling boilers, fired by Detroit stokers, and two 906 indicated horsepower Skinner Universal Unaflow engines, driving 750 kv-a. General Electric 2400-v. generators.

The electric load varies considerably, ranging from a base load, for fans and pumping, of about 200-kw. to a peak of 1500-kw. Both the generating and boiler equipment was selected to meet these rapidly fluctuating load conditions, using either cleaned or refuse coal.

Fig. 1. Engine room showing one of the two 750 kv.a. units

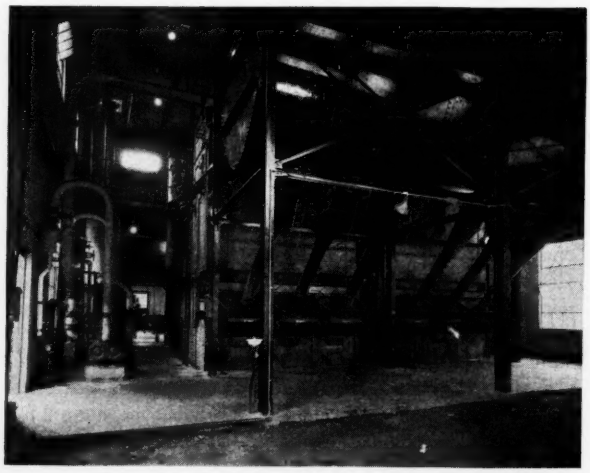


Fig. 2. Boiler room with two boilers installed and space for two more

The furnace and stoker arrangement is such that the finer coal particles are burned in suspension in the furnace while the larger sizes drop and burn on the stationary grates. Stokers are in three sections using forced draft and have Hagan automatic combustion control. Raw water direct from the mines is used for boiler feed in conjunction with the Hall Laboratories phosphate treatment.

List of Power Plant Equipment in the Lillybrook Coal Co. Plant

Engines—Skinner Engine Co., 2, 906 indicated horsepower, 150 r.p.m., horizontal Universal unaflows, with auxiliary exhaust valves. Each engine drives a General Electric Co. 750 kv-a., 3 phase, 60 cycle, 2400-v. generator at 150 r.p.m.

Exciters—General Electric Co., 2, 20-kw., 125-v., driven at 850 r.p.m. by Bluefield Supply Co. Multiple V-belts.

Switchboard—General Electric Co., 9 panels, made of 1½ in. ebony asbestos. Instruments and equipment include disconnecting switches, electrostatic ground detector, synchroscope, frequency indicator, voltmeters, ammeters, indicating wattmeters, totalizing watthour demand meter, individual circuit totalizing watthour meters, overload relays.

Voltage Regulators—Allis-Chalmers Mfg. Co., Brown-Boveri rocking contact type.

Boilers—Babcock & Wilcox Co., 2, 5070 sq. ft., 800 lb., W.S.P., type H. 3 fusion welded drum Stirlings, 24 tubes wide, set with the center line of the mud drum 12 ft. above the floor.

Stokers—Detroit Stoker Co., 2, 96 sq. ft. stokers, built in three sections, driven by 2-hp., 1800 r.p.m., 440-v. General Electric motors through V-belt drive.

Chimney—Alphons Custodis Chimney Construction Co., 178 ft. 6 in. high reinforced concrete, 6 ft. 6 in. I.D. at top.

Forced Draft Fans—Clarage Fan Co., 2, size 2, type HSV, each driven by a D.E. Whiton Machine Co. 17-hp., 1500 r.p.m., 2 stage turbine.

Feedwater Heater—Elliott Co., 1, 1500-hp. vertical cast iron open type.

Boiler Feed Pumps—Worthington Pump and Machinery Corp., 2, 10 by 6 by 12 in. horizontal duplex piston type.

Coal Storage—Virginia Bridge & Iron Co., 72-t. bunkers.

Coal Handling—Kanawha Mfg. Co., consisting of a rotary mine car dump, apron feeder, single roll crusher and 24 in. belt conveyor.

Soot Blowers—Diamond Power Specialty Corp.

Feedwater Regulators—Bailey Meter Co.

Boiler Non-Return Valves—Golden Anderson Valve Specialty Co.

Combustion Control—Hagan Corp.

Pump Governor—Bailey Meter Co.

Back Pressure Control—Hagan Corp.

Boiler Water Conditioning—Hall Laboratories.

Roofing and Ventilators — Johns-Manville.

Valves and Piping—Crane Co.

Pipe Covering—Johns-Manville.

Piping Contractors—Peck, Hannaford & Peck Co.

Steel Work—Truscon Steel Co., building, steel frame work, sash and door, concrete block walls, corrugated asbestos and cement roofing ventilators. Boiler room 50 ft. 8 in. wide, 35 ft. long, 30 ft. to the eaves. Engine room 50 ft. 8 in. wide, 49 ft. long, 16 ft. to the eaves.

Unit Heating Installations

In recent years unit heaters have gained considerably in popularity, not only in the country but abroad. In this article which is abstracted from the Journal of the Institution of Heating & Ventilating Engineers we present the English point of view of these heaters, a view practically identical with our own.

By F. M. Ware
Institution of Heating & Ventilating Engineers

IN RECENT YEARS THE unit type heater has gained considerable favor for certain classes of heating installations. As their performance has become better understood and as manufacturers of these heaters have issued more comprehensive tables and data on their operating characteristics their selection to meet certain requirements has been simplified.

It is therefore my purpose, in this discussion, to give, in a practical manner, an outline of the opinions formed in the course of my own experience in handling this particular class of work.

The main advantages to be gained by the adoption of unit heaters, comparative to direct radiation, are as follows: (1) Warmth is evenly distributed and circulated near floor-level and within the working zone.

This is one of the outstanding advantages of unit heating, since, with direct radiation, it is seldom convenient to situate the radiating surface in any position other than overhead. (2) Where steam is available, rapid warming-up is obtained, provided always that the steam and condensate mains are of adequate capacity to deal with the initial higher output of the unit heaters, and free drainage of condensate maintained.

Further, in cases where a building is only intermittently warmed, considerable economy in fuel would result, owing to the fact that the steam-content of the mains themselves is very small, whilst with a low-pressure hot-water job, consisting, say, of overhead pipes, the heat initially absorbed by the water in raising the required surface temperature, always very considerable in amount, is entirely wasted.

Owing to the low thermal content, time-lag is greatly reduced, rendering the unit-heater installation particularly suitable for thermostatic control.

(3) In order to keep low the cost of factory buildings, they are now, usually of very light construction, frequently steel-framed and lined along walls and roof with asbestos sheeting or protected metal.

These particular building materials are highly heat-transparent, and if hot radiating surfaces are installed in close proximity to same, heat will be much more rapidly transmitted to the external air than would be the case where unit heating is employed. (4) If the unit heaters are coupled to the outside air by means of suitable steel ducting, with a recirculating damper, they can in summer, be employed for the purpose of introducing and circulating a supply of cool air into the building.

A few remarks upon the types of unit heaters now commonly met with will not be out of place.

Industrial Floor Type

This consists of a heater battery contained within a cylindrical sheet-steel casing, air being blown by means of the fan, over the battery, and discharged near floor-level through the bottom of the machine.

This type is particularly limited in its practical application owing to the fact that it is suitable for dealing with isolated areas only, and does not lend itself to any scheme whereby the warmed air can be kept in constant circulation.

Cabinet Type

This consists of a rectangular steel casing containing a heating battery through which air is drawn by a centrifugal type fan and distributed at a velocity of about 1500 ft. per min. above the heads of the operatives, the return circuit of the air being along the floor-level, thence to be drawn again over the heating battery and recirculated.

The main disadvantages of these heaters is that owing to their great air output and high velocity, if the battery should be shut off or become water-logged, and the fan left running, strong and objectionable drafts are soon felt.

Suspended Type

What is by far the most popular and adaptable type of heater unit, is that usually known as the "suspended type."

This consists of a battery of copper-finned tubes with collecting headers, enclosed within a sheet-steel casing having adjustable louvre plates on the discharge face, for the purpose of exercising control in the directional route of the warm air.

The motive power usually consists of a motor-driven fan mounted at the rear of the assembly.

These, again, may be divided into two types, those having a square outlet face and a single fan and motor, and those having an oblong horizontal face and two motor fans.

The outlet velocity of this type of unit heater is usually in the region of 900 to 1200 ft. per min., at which velocity the output will be about three times as great as would be obtained from the battery without the use of the fan.

The great advantage attaching to this particular type of unit is its low cost, and the fact that by reason of its moderate output in comparison to the cabinet type, a better distribution of heat can be obtained by the use at a competitive figure, of a larger number of units.

Selection of Units

When selecting a unit heater, particular attention should be paid to the final temperature of the warm air delivered. Within reasonable limits the lower the final temperature the more positive is the movement in the desired direction. This point is of particular importance in lofty buildings where the units have frequently to be fixed at a greater height than that which is considered advisable by the manufacturers themselves.

It also follows that, for a given output in B.t.u., the lower the final temperature, the greater will be the quantity of air delivered, an important consideration where the units are to be used during the summer months for ventilating purposes.

When preparing the layout of the units, it is advisable that they should be allocated to such positions from which they may deliver towards the outside walls of the building in an oblique direction. This will eliminate to a large extent cold spots and draughts through doors and windows. It is most important that the arrangement be such that a continuous current of air is moved right round the building. Generally speaking, the units should not be situated at a height greater than about 15 ft., except in the case of the largest sizes, where I have known them to be fixed with entirely satisfactory results at a height of 20 to 22 ft.

It is my own experience that unit heaters having a face area of less than 15 in. by 15 in. are unsuitable for industrial heating, but may usefully be employed in small rooms or workshops where the height is not too great, or where length of range is not required.

When dealing with long narrow buildings care should be taken to ensure that the units are not situated on the longer walls, to blow towards the opposite side, as this will surely result in cold spots, and possibly down-draught.

Layout of Mains

When employing steam as the heating medium it is usual for the steam and condensate mains to be fixed above the roof trusses, the unit heaters being suspended below.

It will be readily appreciated that when the installation is based upon output with recirculating air, the initial steam consumption when starting up will be much greater than on normal operation, owing to the lower temperature of the air passing through the units, and both steam and condensate mains must be capable of dealing with the starting load, if rapid heating-up and constant steam pressure are to be obtained.

The steam service to each unit should be taken directly off the top of the main to insure dry steam being obtained and the condensate should be trapped and lifted back into the top of the condensate main, from which point a gravity flow back to the hot-well should be arranged.

The two-pipe open-return system is undoubtedly the most satisfactory in operation, and in my experience, the best all-round performance is to be obtained at pressures between 15 and 30 lb. per sq. in., which can readily be maintained without too constant attention to the boiler plant. It will be found that it is unwise to base upon the higher pressures of, say, 80 to 120 lb. per sq. in., as these in practice are seldom constantly maintained with the average type of boiler plant used on factory jobs.

It will be found that when employing the lower pressures one or two extra unit heaters will be required to obtain the necessary output, but this extra will be approximately counterbalanced by the reduced cost of the boiler for the lower pressure.

When dealing with lofty buildings, having a considerable amount of roof glazing, it is advisable to provide a pipe coil directly under the glazed surfaces to reduce down-draught. This surface can usually be obtained by a suitable layout of the steam mains themselves, without calling for any special pipe coils.

Where hot water is used as the heating medium, it is necessary, on installations of any magnitude, to incorporate an accelerator pump, so that the sizes of the distributing mains may be kept within reasonable and economic limits.

Electrical Control Gear

Each unit heater should be provided with a separate ironclad switchfuse unit so as to obtain independent isolation at each point in case of emergency or breakdown.

The unit heaters lend themselves particularly to thermostatic control, owing to the reduction of the time-lag brought about by the lower thermal content of the apparatus itself, and any number of units can be controlled by means of a single thermostat inserted in the leads to the main distribution board.

If an automatic oil burner, or mechanical stoker, is employed it is quite a practical proposition, to obtain what may, in every respect be termed a "fully automatic plant," by installing an electrically-driven feed-pump operated by an electric float-switch controlled by the actual working level of the water in the boiler itself.

If thermostatic controls are employed, care must be taken to see that they are placed in such a position as to be clear from impinging drafts, failure in this respect may lead to serious waste of fuel through the heaters cutting in unnecessarily.

In closing, a few remarks about fuel and electrical consumption will no doubt be expected.

Electrical consumption is very small, almost negligible in relation to the amount of heat delivered by the unit heater.

As an instance, a unit having a ½ hp. motor consuming about 400 watts per hour, when supplied with steam at 30 lb. per sq. in., will deliver up to about 400,000 B.t.u. per hr.

Lubrication Methods *for Rod Packing*

Shut-downs and Many Other Engine and Pump Troubles Can Be Avoided by Proper Attention to Packing and Its Lubrication. By Fred S. Rutledge

IN OUR POWER plant we have one 16 by 30 by 42-in., 78 r.p.m. and one 24 by 48 by 48-in., 72 r.p.m. cross compound engines, running condensing; one 5¼ by 3¼ by 5¼-in. duplex pump for pumping water for house service against 103 ft. head; one 10 by 7½ by 10-in. simplex pump for the same service, when demand becomes too great for the duplex; one 7 by 5 by 12-in. duplex pump for pumping water from hot well of condenser into open feedwater heater; one 18¼ by 10¼ by 12-in. duplex fire pump, capacity on last test, 850 g.p.m. at 72 strokes per min., 140 lb. nozzle pressure and 120 lb. gage pressure at boilers. These pumps are all inside packed except a 10 by 6 by 12-in. outside packed duplex, used for boiler washing, or it can be used to feed the boilers or is also piped up so that it can be used in case of emergency as an additional fire pump; and one 7 by 8-in. belt-driven triplex pump for boiler feeding.

This gives a fair idea of what our packing demands are. The high pressure rods of the engines are packed with asbestos metallic packing having a gum or rubber core, body of asbestos composition and a woven copper wire jacket around the whole. This packing is cut to the proper length and then laid in a warm place.

Method of Packing

After the old packing is thoroughly cleaned out, dry flaked graphite is blown into the stuffing box. Then the packing is given a good coating of a paste made of flake graphite and cylinder oil mixed to about the consistency of butter. The stuffing box is filled with packing, being sure to break joints to a point where the gland will just enter.

Each ring is pushed in as far as possible with a stick and then followed up with the gland until well seated. The gland is then slacked off and the nuts tightened with the fingers and left that way until after the rod has been run for a few minutes when about ½ turn of the nuts is usually enough to stop any leakage.

All the rods on the steam pumps are packed the same way except the smaller ones. A composition braided packing is used on these. The same system is used in packing the low pressure rods of the engines except a composition packing, already made up into rings of the required size, is used.

High pressure valve stems, on the engines, are packed with a packing made of lead and asbestos, Fig. 1, A and B. Low pressure valve stems are packed with composition rings of a soft packing. Graphite paste is used in all cases. Stuffing boxes on engine piston rods are all fitted with a ⅛-in. pipe connected to an oil pump, separate feed for each rod being provided as indicated in Fig. 2. From 4 to 6 drops are fed per minute according to the size and pressure.

Routine Oiling for Valve Bonnets

Valve bonnets have a ⅛-in. hole drilled as in Fig. 3. Cylinder oil is used in these oil holes, being filled every 2 hr. when the motion work is oiled. These engines are 40 yr. old and, except in the case of the high pressure cylinder of the 24 by 48-in. engine, which was wrecked in starting up, have the original piston rods and valve stems. Piston rods are swabbed every hour with cylinder oil and flake graphite. Three tablespoonfuls of graphite to each two quarts of oil. Rods are nice and smooth and of a bluish black color. I have never seen a hot rod since being on the job, 2½ yr. and all the work that has been done on any of them in that time was one ring added on the high pressure rod of the big engine. The boiler pressure carried is 140 lb. gage when this engine runs and the load varies from 850 i.hp. to, at one time, as high as 1400 i.hp. Vacuum carried is 22½ to 24 in.

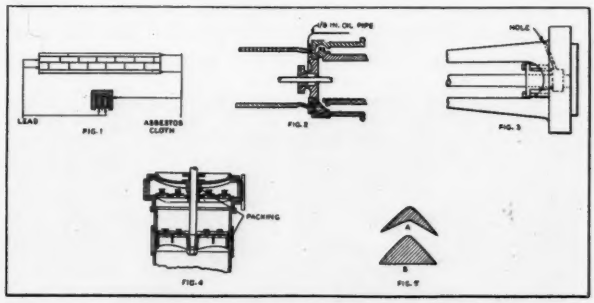


Fig. 1. Lead and asbestos packing for high-pressure valve stems
Fig 2. Location of oil pipe to stuffing box
Fig. 3. Oil hole used to lubricate valve bonnet
Fig. 4. Section through condenser
Fig. 5. Cross-sections of special packing used on boiler feed pump plungers

Figure 4 gives an idea of what the condenser is like. It, too, has a packing problem, or did have. It is

in reality a pump, having valves in the piston or bucket. This piston is quite a sensitive proposition about packing as it is driven by its own steam cylinder and valve and if the packing is too tight, the packing in load it does get hot at times.

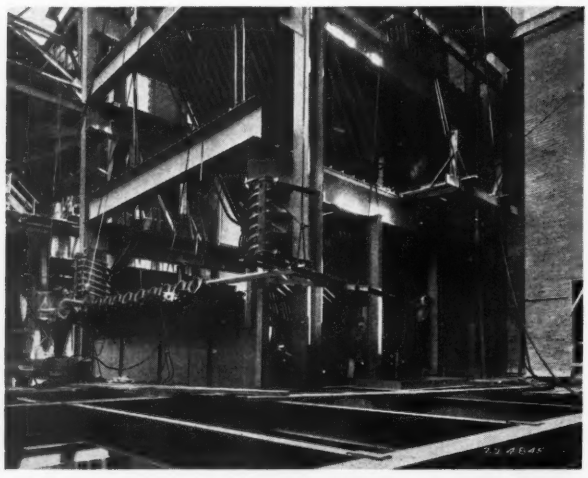
Packing is cut 1½ in. short of reaching around the piston, or bucket. One ring of canvas hydraulic packing, thoroughly covered with a grease of about the consistency of vaseline, is put in first and the remainder filled with braided flax, also well covered with a layer of grease between packing rings. Care is taken in tightening the follower ring. The piston rod is packed with one ring of the asbestos metallic packing used on the high pressure engine pistons because the rod is worn and if only braided flax is used it works through between the rod and hole in the valve deck. Plenty of grease is used on the packing used here and since the grease has been used, no further wear has developed on the rod.

Packing used on the water end pistons of all pumps, except the triplex boiler feed, is braided flax well greased, regardless of whether they are outside or inside packed. The triplex boiler feed pump plungers are packed with a special packing shaped like Fig. 5A. Figure 5B is the shape of packing to be put in first and the remainder of the space is filled with rings the shape of Fig. 5A. Graphite and cylinder oil paste are applied when packing is put in and the plungers are swabbed once an hour with a thick paste of graphite and oil, when running.

Records are kept of all packing renewals and amount of packing used and, according to them, this pump was packed October 30, 1930, and since I came on the job only one ring has been added on No. 3 plunger which is slightly scored in one spot.

Westinghouse Boiler Plant

CONSTRUCTION ON THE new boiler house and the first of a group of four boilers is well under way at the East Pittsburgh Works of the Westinghouse Electric and Manufacturing Company. When completed this first



1600 hp. boiler will be used for plant process and heating purposes and will be capable of operating at pressures up to 600 lb. The building and boiler are being constructed at a cost of $400,000.

Principles and Characteristics of Electric Motors

Continued from p. 521

in the rotor circuit is induced by the magnetic field of the stator winding.

Rotation of the rotor is produced by means of a revolving field, the latter being the result of two or more alternating magnetic fields, displaced in time. The principle is illustrated in Fig. 5. For the sake of simplicity a two phase system is shown but the principle involved is the same for a three phase system. This diagram shows a two phase induction motor (the rotor of the motor is not shown for simplicity) connected to a two phase generator. As the generator rotor revolves, two phase current is generated which

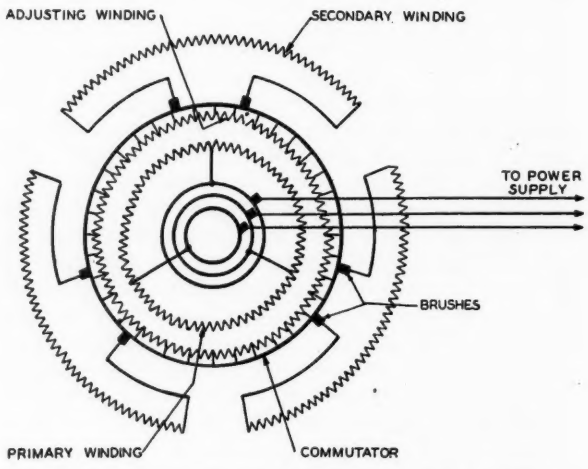


Fig. 6. Commutating type of polyphase induction motor

is transmitted to the motor, one of the phases magnetizing one set of stator poles and the other the other set. At the instant shown in diagram A the current in the phase connected to poles AB is at a maximum while in the phase connected to poles CD it is zero, hence poles A and B are magnetized while C and D are not. Thus the field is as shown, occupying a vertical position. An instant later when the generator has reached the position shown in diagram B, the currents in the two phases are equal and both sets of motor poles are magnetized. Thus the direction of the field is inclined at an angle of 45 degrees. And so on; when the generator rotor has turned through a quarter of a revolution, the motor field will have done likewise as shown at C. In this manner, the motor field continually follows the motion of the generator rotor and if a revolving magnet were placed in the center, it also would revolve.

In practice, however, a closed winding is placed within the motor field. This field cutting the conductors of the winding induces in it a current and the magnetic field resulting from this current in the rotor will be acted upon by the revolving field due to the stator poles so as to cause the closed winding to revolve. In order that a current may be induced in the rotor winding it is necessary that there be relative motion between the rotor and stator, for if there were

not, there would be no cutting of the stator flux by the rotor conductors. As the load is applied to the rotor, it slows down. The revolving field, however, rotates at a constant speed. Hence, as the rotor slows down, the revolving flux cuts the rotor conductors, inducing in them the higher currents necessary to develop a turning effort upon the rotor. This difference in speed between the revolving field and the rotor in an induction motor is called the "slip." The rotor is said to slip a certain number of revolutions behind the revolving magnetic field. As the load is increased the slip increases resulting in greater current in the rotor and therefore greater turning effort to carry the load.

So much for the principle upon which the induction motor operates. Let us now see how the various types shown in the table vary. The two principal types are the squirrel cage and the wound rotor types.

These differences apply primarily to the construction of the rotors. In the squirrel cage type the rotor winding consists simply of copper bars embedded in slots in the iron core of the rotor and connected at each end by copper rings. The rotor winding thus forms a complete closed circuit in itself. In the wound rotor type, the winding is of insulated wires similar to that of a direct current winding. The ends of this winding are usually brought out to collector rings on the shaft and is not closed until the collector rings are connected together directly or through resistances for purposes of speed control.

In the commutating type of polyphase induction motor the relative location of the two windings is reversed from that which obtains in the ordinary induction motor. The arrangement is shown in Fig. 6. As will be noted, the rotor winding is connected to the external power supply. The rotor also carries a second winding which is connected to a commutator as shown. The position of these brushes can be shifted, in practice, either by hand or by a motor driven mechanism from a remote point. When the brushes of each phase are together resting on the same commutator segment, the secondary winding is short circuited and the motor operates as a squirrel cage motor. Moving the brushes apart, however, introduces a portion of the adjusting winding in series with the secondary and impresses an additional voltage on it. When the brushes are moved in one direction this voltage opposes the normal induced voltage in the secondary, causing a decrease in speed; when moved in the other direction the voltage from the adjusting winding is added to the one induced in the secondary by the revolving field.

Synchronous motors are essentially the same as ordinary alternating current generators but usually in addition to the ordinary winding are provided with an auxiliary winding similar to a squirrel cage winding embedded in the pole faces. They require a separate source of direct current excitation just as does an alternating current generator. One great advantage of the synchronous motor is that the power factor is always under the control of the operator, depending upon the adjustment of the field current. Because of this characteristic synchronous motors can be used to furnish leading reactive current for correcting the low power of the system. When used primarily for this purpose, it is called a synchronous condenser, since its action electrically is equivalent to that of a condenser.

The principle of the synchronous motor is based on the fact that unlike poles attract each other. The synchronous motor, like the synchronous generator consists of a stator winding with a certain number of poles per phase, and a rotor, having a number of poles corresponding to the number of poles per phase of the stator. The rotor poles are excited by direct current. Each south pole of the rotor tends to take a place directly opposite a north pole of the stator. The field produced by the stator, however, revolves at synchronous speed; hence in order that the rotor poles may maintain their positions opposite the stator poles, the rotor also revolves at the same speed as the stator field, that is, at synchronous speed.

It is evident, therefore, that the synchronous motor is a constant speed machine and is not subject to speed control. Its speed is entirely a function of the frequency of the supply system. When the motor is running without load the axes of the rotor poles approximately coincide with the axes of the stator poles. When load is added, however, the position of the rotor lags slightly, not in speed but in angular position, and the forces of magnetic attraction then have tangential components which develop torque. With increasing load and consequent increasing displacement the tangential pull increases until the displacement reaches 90 deg. (magnetically). Beyond this point the operation becomes unstable and the motor pulls out of step. When the displacement is 180 magnetic degrees, like poles of course will be opposed and no torque will be produced.

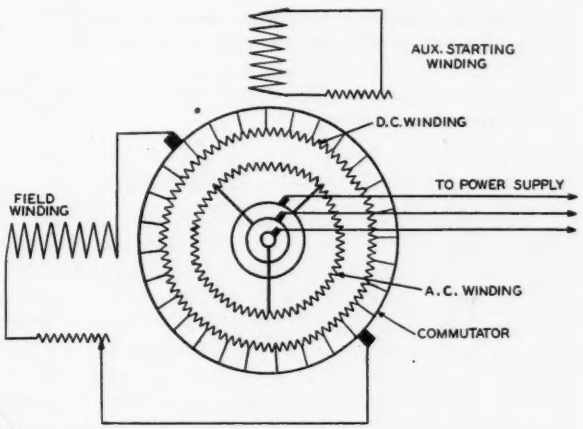


Fig. 7. Fynn Weichsel motor

The synchronous motor as has already been pointed out has several disadvantages. First, a separate source of excitation is necessary; second they have poor starting characteristics and must at all times maintain synchronous speed. To overcome these disadvantages special types of synchronous motors have been developed, most notably the Fynn-Weichsel motor. This is a self exciting synchronous motor carrying two windings, one a direct current winding connected to a commutator and the other a three phase winding

connected to slip rings. The stator also is provided with two windings, displaced 90 electrical degrees. One of those windings is normally short circuited while the other is connected to the d.c. brushes. In starting, the alternating current rotor winding operates as the primary of an induction motor and the two stator windings function as the secondary of a wound rotor induction motor with external resistance. As the motor speeds up the resistances in the stator circuit are cut out until one of the stator windings is short circuited and the other is directly in series with the d.c.

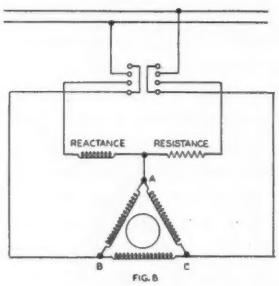


FIG. 8

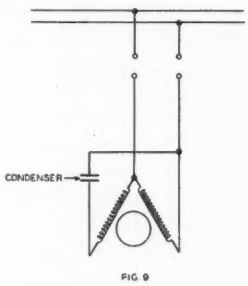


FIG. 9

Fig. 8. Inductively split phase motor connections
Fig. 9. Capacitor split phase motor connections

winding on the rotor. The motor then pulls into step as a synchronous motor.

Single Phase A.C. Motors

The question of single phase alternating current motors can best be approached by a reconsideration of the series wound direct current motor. In this motor, the field and armature are in series and the current in both elements is always in the same relative direction. If in the operation of such a motor on a direct current circuit, the line terminals are suddenly reversed, it will make no difference, the motor will continue to run in the same direction. The reversals of current in the field and armature are simultaneous and the direction of torque remains unchanged. It is evident then that such a motor would operate on alternating current though to enable it to do so practically requires that a number of modifications be made. The solid field poles must be replaced by laminated ones otherwise the rapidly alternating flux will cause excessive eddy currents with consequent heating. Also, the field winding must be designed with lower inductance. With these changes and a few others of less importance the series type commutator motor operates satisfactorily on alternating current. It finds its greatest application in fractional horsepower service, the so-called "Universal" type motors adapted for use either on alternating or direct current as may be necessary being of this type.

The type of single phase motor in more general use than the series motor is the single phase induction motor. This is built very much on the order of the polyphase motor but, of course, is provided with only one set of windings. In such a motor there is no rotating field as in the polyphase motor, but if the rotor in such a motor is brought up or close to synchronous speed it will continue to revolve and will produce torque. It is therefore necessary with this type of motor to provide some method for starting. Single phase motors, therefore, are divided into several classifications depending upon the method used for starting. These are as follows: 1, shading coil; 2, inductively split phase; 3, capacity split phase; 4, repulsion start, induction run; and 5, repulsion induction.

The most common type in use, however, is the inductively split phase type, though recently the capacitor type has gained popularity. This motor (the inductively split phase) is provided with external resistance and reactance as shown in Fig. 8. At starting the switch connects the resistance in parallel with the stator phase AC or in series with stator phase AB while the reactance is in series with AC and in parallel with AB. The line voltage is impressed directly on stator phase BC. This arrangement so modifies the phase and magnitude of the voltages on the respective parts of the stator winding that an approximate three phase condition is obtained and a rotating field set up. When nearly synchronous speed is obtained the switch is thrown over and only the stator phase BC will be in use. Thus the motor continues to run single phase. The switch as a rule is built integral with the rotor and is operated automatically by centrifugal action.

In capacitor motors the necessary phase displacement between the currents of the two stator windings is produced by placing a condenser in series with an auxiliary winding as shown in Fig. 9. The two stator windings are displaced 90 electrical degrees. The effect, of course, is very much the same as that obtained in the inductively split phase motor, the condenser producing a voltage 90 deg. out of phase with the line voltage. In the capacitor motor, however, both windings are permanently connected to the supply during both starting and running.

Of the other types of single phase motors little need be said. The repulsion motor has an armature similar to that of a direct current motor and has two brushes which short circuit the armature. In the straight repulsion motor the motor operates permanently as a repulsion motor. In the repulsion-induction motor the motor starts by repulsion motor action but runs as an induction motor. In the shading coil motor, the stator winding is not distributed in slots but is wound on projecting poles. In addition to the main winding around these poles, a shading coil is placed around one side of the pole piece. This makes the flux in that portion of the pole piece lag behind the flux in the other part of the pole.

Speed Control of Electric Motors

There are various ways in which the speed of electric motors can be controlled but some motors are much more flexible in this respect than others. Direct current motors are inherently more adaptable to speed control than are alternating current motors, although with certain modifications alternating motors can be adapted to various degrees of speed control. In general, the speed of motors can be controlled by the following methods: 1, Changing impressed voltage; 2, changing voltage across stator or rotor circuits; 3, changing the frequency of the supply; 4, changing the number of poles; 5, introducing foreign voltage or

voltages in certain of the windings; 6, operating two or more motors in cascade.

In the operation of direct current motors the first two methods are most generally used, the first for series motors and the second for shunt and compound motors. The speed of a shunt wound motor may be decreased below normal by placing a rheostatic controller in series with the armature and it may be increased above normal by means of a resistance in

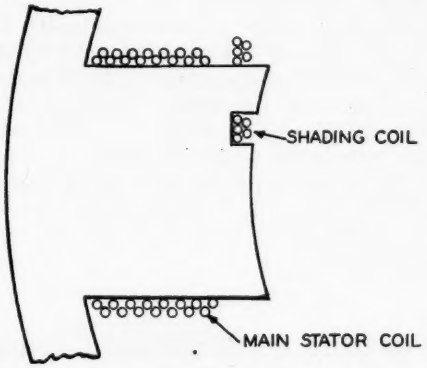


Fig. 10. Pole piece showing use of shading coil

the field. This amounts to a reduction of the voltage across the armature and fields respectively. In the case of a series motor the same effects are obtained by shunting the resistance across the field or armature though it is more common with series motors to place the resistance in series with the motor itself thus reducing the impressed voltage. This, of course, involves a considerable loss of power in the rheostat which is a disadvantage but since series motors requiring speed control are used largely for intermittent service this loss is not serious. In the case of the shunt and compound motors, field resistance control is most efficient since the field current is much smaller than the armature current and the losses therefore are proportionately less. With field control, the speed remains practically constant when once adjusted regardless of change in load. With armature rheostatic control this does not hold. Though the speed may be reduced below normal for any load this speed will not remain constant as the load varies. Armature control is not used to any considerable extent except where a greater speed range is necessary than can be obtained by field control.

Induction motors are less adaptable to speed control than are direct current motors, particularly the squirrel cage type. The speed of the wound rotor type can be varied by inserting resistance in series with the rotor circuit. This method of speed control while effective is subject to the same disadvantage that armature control has in direct current work, the speed does not remain constant with change in load and a considerable amount of power is lost in the external resistance.

A more efficient and more effective method of speed control is obtained by introducing a foreign voltage in the secondary circuit. This is the principle used in the brush shifting motor and shown in Fig. 6. If this foreign voltage acts in a direction opposite to that of the voltage induced in the secondary circuit the speed is reduced; if in the same direction the speed is increased. The actual control of this foreign voltage is obtained by shifting the brushes as already described. With this method of control no power is wasted in resistances and the speed is practically constant for all loads when adjusted by any condition.

When the arrangement of drive permits the method of connecting two wound rotor induction motors in cascade is an efficient method of control. With this system the rotors of two or more motors are mounted on one shaft or the shafts rigidly connected. The primary of the first motor is connected to the line. The secondary of this motor then is connected to the primary of the second motor, and so on. The secondary of the last motor is connected to a resistance or it may be of the squirrel cage type. Speed control is obtained by varying the connections of the motors. For example, each motor can operate at normal speed with its primary connected to the line, the other motors running idle. The motors can be connected so that their rotors tend to operate in the same direction or they can be connected to oppose each other. Or, if the motors have different numbers of poles, different combinations will give different speeds. This method of speed control is flexible and very efficient and is well adapted for use where high power outputs are required.

For certain applications where several different speeds are required but where it is not necessary that a gradual speed control be provided, the method referred to under method 4 in the above list is very effective. In this case the motor is provided with primary windings which are so arranged that different numbers of poles are produced depending upon how the windings are connected.

Finally there is the method of speed control by variation of the frequency of the primary current. Since the speed of induction motor is a function of the frequency, it follows that if the frequency of the supply is varied the speed of the motor will change. This method of speed control naturally is applicable only when a single generator operates one motor or where a number of motors all require their speed to vary simultaneously. Recently vacuum tube equipment has been developed whereby the frequency of any current can be varied between wide limits. Should this prove commercially feasible it will make possible a more effective form of speed control for alternating current motors than any method thus far developed.

Synchronous motors, of course, are not adaptable to speed control except by this last method, variation of frequency.

ONE ENGINEER of broad practical experience, when he has a problem to solve, asks all his friends, the steam fitter, the boiler-room operative, even students how they would solve it. He says, "Of course I can work out a solution but I don't know whether my plan is the best. Often somebody makes a simple suggestion that is better or may be combined with my idea. Nobody has a monopoly on good ideas."

LINK-BELT NEWS.

Readers' Conference

Tank Car Capacities

FUEL OIL is commonly shipped in tank cars which hold 8000 or 10,000 gal. Sometimes it is convenient to know how much has been unloaded at a given time. Occasionally the car does not seem to be quite up to capacity and it is at least some satisfaction to know how much it is short even though it is often difficult to do anything about this shortage unless it is a regular occurrence.

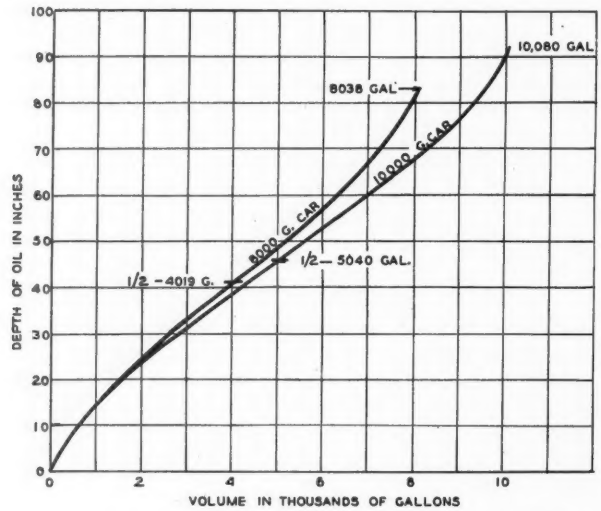


Fig. 1. Volume of tank cars as a function of the depth of oil

In checking up it is well to remember that oil changes in volume about one per cent for each 25 deg. F. change in temperature and it is usually sold at 60 deg. In very cold weather this makes quite a difference, perhaps a foot in the top of the car. The capacity of the dome is small ranging from about 4½ gal. for 36 in. dia. domes to somewhat over 12 gal. for 60 in. dia. domes.

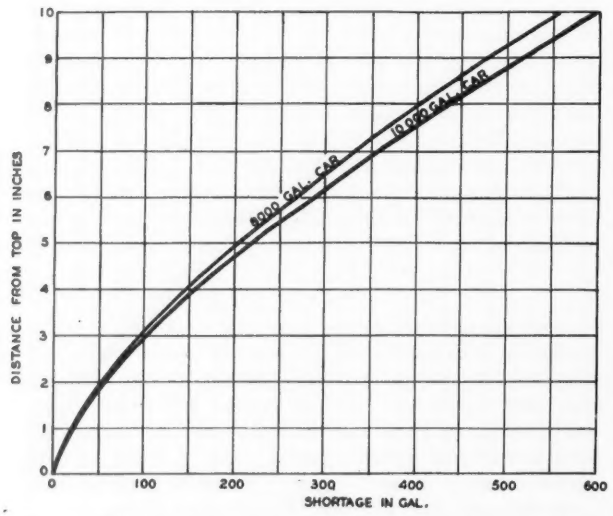


Fig. 2. Tank car shortages as a function of the air space above the oil at 60 deg. F.

As a rule it is easier to measure the depth of the oil in the car than to measure the empty space above the oil and the chart, Fig. 1, given is made in that way, that is, the capacity for various depths of oil in the car. These charts are applicable to either size cars and have been found extremely handy to the writer. As the scale of the complete car load is too small to read very closely the Fig. 2 curves can be used to determine the volume or shortage in a car not quite full.

Brooklyn, N. Y. F. PAUL.

Superheaters for Increased Efficiency of Power Plants

WHEN LOOKING over old plants for possible chances to improve operating efficiency the superheater is usually an excellent place to begin. Few old plants have superheaters, especially if h.r.t. boilers are used. This is because the importance of superheat was not fully realized in the old days and superheaters were not available for boilers of this type. Now they may be obtained in several designs one of which is simply strapped around the rear end of the boiler back of the bridge wall. Being close to the fire and subject to radiant heat and at the same time being swept by the gases the characteristic, that is, the variation in temperature with the flow, should be very good.

Of course with straight tube or bent tube boilers superheaters can easily be added. For additions of this kind or for low or moderate superheats the tubes are usually placed between the first and second pass. There is usually room at this point to install and support it. Of course with some of the newer high pressure and high superheat boilers with all the lower tubes in the first pass it is now common to split the boiler tubes into two banks and put the superheater between them in what is known as an interdeck location. Except in very unusual cases where the boiler was being completely rebuilt such a superheater would not be used in bringing up the efficiency of an industrial plant.

Of course there are many industrial plants where superheaters are already in use. Conditions can often be improved materially in plants of this kind by still further increasing the superheat. Sometimes this can be done by adding more superheat or by changing the baffles so as to get hotter gases to flow over the coils. If neither of these methods is practical a booster radiant superheater can be placed in series with the old convection section so as to give more superheat.

This method had been used successfully in a number of industrial plants. In addition to raising the super-

heat this combination of types improves the superheat condition at low loads. Due to the fact that the convection superheater is placed at some distance from the fire practically all the heat is transferred to the steam by convection. At heavy loads there is a lot of gas flowing past and the velocity and consequently the heat transfer is high so that the superheat is high at heavy loads. In a radiant superheater, on the other hand, the superheat increases as the load decreases due to the fact that the furnace does not vary much in temperature and the heat transfer is almost the same at all times. Consequently when only a small amount of steam is flowing through the superheater the temperature is raised much higher. Putting the two in series in proper proportions gives a superheat characteristic that is almost uniform at all loads.

Such booster units are usually made of about 2 in. round pipes bending out about six inches from the rear wall so that they get radiant heat from practically all directions. They are easily installed by taking a few bricks out of the back wall and require a minimum setting or piping changes.

Especially with engines the first few degrees of superheat is important and increases the efficiency many times what theory would indicate primarily because of the decreased initial cylinder condensation. Of course when new engines or turbines are being added to a plant the superheat should be as high as possible but in old plants it must be kept low because the old machines were not built for high temperatures. They will all stand a few degrees superheat, however, and in fixing up an old plant that is a very likely place to begin to figure.

Brooklyn, N. Y. P. F. Rogers.

Overbelting Does Not Pay

I am frequently asked, "Does it pay to overbelt?" This question is commonly asked by belt users because we have so often been told, "Be sure to use belts and pulleys that are amply wide and thick. It doesn't pay to use narrow and thin belts."

Answering the question, however, "Does it pay to overbelt?", the answer is—No! It does not pay to overbelt for the same reason that it doesn't pay to overdo numerous other things including overeating, overdrinking, overtalking, overexerting, and so on.

Another question frequently asked is, "What factor of safety should be used in designing our belt drives?"

The answer to that is: Belting is not given a factor of safety by our best belt drive designers. The aim is to keep stresses below the elastic limit at all times, on shock drives as well as on steady drives. It is considered all right for the stress to "almost" touch the limit of elasticity without actually hitting it, which, in engineering parlance, means that belting is virtually given a factor of safety of unity—perhaps the lowest safety factor applied to any engineering material aside from shear bolts and pins which are intended to break as soon as the dangerous load is reached.

Newark, N. J. W. F. Schaphorst.

Selling Industrial Dump Hydro Power

Fluctuating Business in many manufacturing plants normally run on hydro power derived from their own stations opens the door for more thorough study of the possibilities of selling surplus or dump energy to local utility systems or adjacent industries, where legal conditions permit this. In a plant recently visited it appeared that such dump power could only be sold at 3 mills per kilowatt-hour during the evening and night, when it was the policy to shut down the station from its 2-shift schedule. Yet energy produced by fuel from a steam plant some 50 miles away was brought into the area for general sale, leaving water to spill over the dam in the absence of local storage at the industrial hydro station. Stream flow was down to 25 per cent of normal at the time in question, yielding perhaps 500 kw. If this output had been sold for 10 hr. at 3 mills the night's yield gross would have been $15, so that it would seem to have been worth while to put on an extra man to run off this output if other conditions were favorable.

Cases of this sort should not be pre-judged, but is it not true that many such situations are being overlooked in this time of reduced manufacturing revenues? The trend toward interchange of industrially generated power and utility energy is likely to increase rather than diminish in the new emphasis placed on overall earning power and net benefits. Today the value of power in a community is fixed by many factors, but these are less and less dependent on ownership of plant, provided the economic conditions are satisfactory. A kilowatt-hour shot into a local street lighting system is just as useful if it is obtained from a mill station which would otherwise spill water as if it were derived from a distant station with the transmission factor entering into the cost determination. Here is another good rainy day subject for engineering analysis.

Cambridge, Mass. H. S. Knowlton.

Pipe Insulation; Heating Difficulties

I note Home-made Installation for cold water pipe sweating on page 490 of the October issue. All that is necessary to prevent any cold water pipe from sweating is to keep all outside air warmer than the pipe, from coming into contact with the outside pipe surface. In covering, such cardboard must be applied carefully. Any thin water-proof material which will be air-proof will be suitable, if it is flexible, and in my opinion will be better than cardboard.

On page 487 of the same issue, there is an article on Heating System Difficulties with which I do not fully agree. In steam heating the main item is proper fall on the feed and return pipe, and the removal of all air from the mains and cast-iron radiators or pipe coils. If the system is properly installed, all radiators and coils will heat, irrespective of how many radiators or pipe coil returns go to a steam trap. Of course the trap must be properly vented. Only automatically operated valves are necessary on a properly vented system.

Toronto, Ont. James E. Noble.

Identifying Pipe Materials

SOMETIME AGO you had a short article on the indentification of iron and steel pipe by means of acid. Sometimes acid is not handy and there are two or three other methods that may be used by those familiar with the physical action of the two kinds of pipe when subjected to different tests. Often it is possible to examine the cuttings when the pipe is being threaded. If they are in long threads or coils the pipe is steel. If they are short chips the pipe is iron. Cast iron pipe is brittle and cannot be dented or bent while wrought iron is ductile and may be flattened with a hammer.

If the pipe is galvanized I have heard that a hammer test can be applied to distinguish the character of the pipe material. If the pipe is hammered flat the galvanizing will flake off the steel pipe under repeated blows but will adhere to the wrought iron as though it were part of the parent metal. Whether or not this is true I have never had an opportunity to verify, all I know is that it does peel off of steel pipe although I was always under the impression that this was because the pipe was not properly cleaned or pickled before galvanizing.

Of course it is not always possible to go around the plant cutting pipe up or hammering it to pieces. In this case a file can usually be used to advantage. If 2 or 3 sq. in. are filed bright and fine lines can be distinguished running parallel with the pipe it is wrought iron, a distinguishing feature of which is slag inclusions which in rolling are drawn out into fine lines. If these lines are not present the pipe is steel. That is unless it is cast iron, which most engineers can usually identify without much difficulty.

Brooklyn, N. Y. P. F. ROGERS.

Home-Made Trap to Remove Excess Air

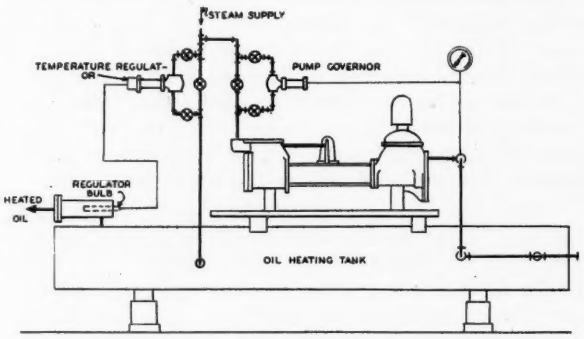
LOOKING OVER the pages in the September issue of Power Plant Engineering, I note the article by E. W. Winkler on page 435, namely, "Home-Made Trap to Remove Excess Air From Water Pipes."

In my opinion the trap is not necessary. I have installed many pumps in deep wells during my working lifetime and I never found any air trap necessary. Not many men will go to the trouble of making such a complicated and, in my opinion, useless piece of apparatus. Another thing, water under a pressure of 40 lb. to the square inch will not expand and be sprayed over a room as described by Mr. Winkler; the water will be trapped and the air will be removed when the faucet is opened. Many delivery pipes from deep well pumps will be empty at times. Should air be delivered to the house supply pipe, such air will usually escape at the tank when the water is delivered there. If there is no tank the air will usually go to the highest point of the delivery pipe where an automatic or other valve will take care of it. Water may spatter to a certain extent but not to any great amount if there is air when a faucet is opened at any location but it will not be sprayed over a room as Mr. Winkler assumes.

Toronto, Canada. JAMES E. NOBLE.

How Can I Control Oil Temperature to Our Boilers?

POWER PLANT ENGINEERS who are burning oil under their boilers are asking the above question. They would like to know how oil temperature can be positively regulated and held at the desired point.



TEMPERATURE REGULATOR AND PUMP GOVERNOR CONTROL OIL TEMPERATURE

Herewith is a sketch which shows clearly how to do it. A temperature regulator bulb is placed in the fuel oil pipe close to the point of exit. This bulb, through its temperature regulator, causes steam to be turned off and on as required to maintain the desired temperature, the steam being by-passed through the temperature regulator as shown.

At the same time, a pump governor, shown directly over the steam pump, controls the pressure of the same fuel oil. In other words, temperature and pressure are both simultaneously controlled, using a common source of steam supply.

Newark, N. J. W. F. SCHAPHORST.

Taking Samples of Transformer Oil

WHEN TAKING samples of transformer oil, care must be exercised that the sample does not get contaminated during sampling. Tin cans or clean glass cork stoppered bottles may be used for holding the sample. The containers used should be chemically clean and dry. Glass bottles have the advantage that they will permit a visual inspection of the oil before testing, enabling its freedom from solid impurities and water to be seen. Samples should be kept away from the light, as light causes chemical changes in the oil. Rubber stoppers should never be used with glass containers. For stoppers use only good quality cork, actual contact with the oil can be prevented by wrapping same pure tin foil round the cork before putting in the mouth of the bottle.

Where tin cans are used for holding this oil they should be soldered on the outside.

Herts, England. W. E. WARNER.

HERE IS a new one. A ¾-in. hydraulic pipe in one of the buildings of The B. F. Goodrich Co., Akron, Ohio, developed a noisy water-hammer due to fluctuating pressure, for which no remedy was found until an engineer substituted a piece of ¾-in. hose for a section of the pipe. This ended the trouble at once.

How Far Is the Eccentric Ahead of the Crank

TO THE QUESTION: How far is the eccentric ahead of the crank, on a single eccentric Corliss engine?—the answer has generally been 90 deg. plus lead and lap. But if that answer is not quite satisfactory, perhaps the approximate number of degrees, say 128, will be accepted. Now, if proof be asked, the ordinary throttle choker will shake his head, cock his eye and drawl, "What is this—a catch question?" A simple example will show that it is only a few minutes' work to secure the correct solution.

Figure 1 shows a Corliss engine valve gear diagram with wrist plate in center position; i.e., the center line will be on mark. Each exhaust valve will be line and line. Eccentric will be 90 deg. ahead of the crank, neglecting the slight variation caused by the angularity of the eccentric rod. The above facts being so, then the same will hold true as compression begins. As either exhaust valve starts to close, being line and line, so does compression start.

In Fig. 2 is shown a diagram of crank, connecting rod, and center line of engine. If the Corliss engine be of standard design, then the rod will be six times the radius of the crank. Thus a 48-in. stroke engine should have a 12 ft. rod.

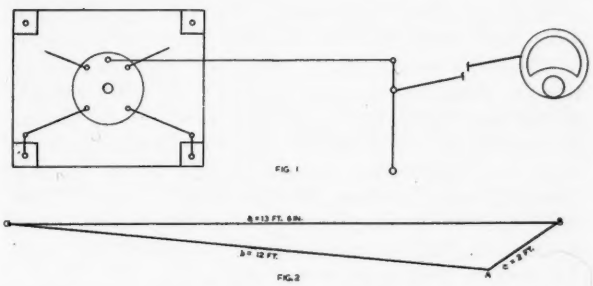


Fig. 1. Diagram of Corliss engine with wrist plate in center position

Fig. 2. Angle B to be found, to determine actual setting of eccentric

Now, when the crank is on the head-end center, the distance from the wrist-pin center to the center of shaft should be, 12 ft. (rod) plus 2 ft. (crank) equals 14 ft. But when compression starts (ordinarily 7/8 stroke), the wrist-pin will be 6 in. from end of stroke. Therefore: When the wrist-pin is 6 in. from end of stroke, eccentric is at 90 deg.

Now it only remains to find the angle made by the center line of engine and center line of crank. This angle added to 90 will be exactly the number of degrees that the eccentric is ahead of the crank. The triangle from which we will work the angle will have (as per Fig. 2) sides of 13 ft. 6 in., 2 ft. and 12 ft. The desired angle will prove to be approximately 38 deg. 32 min., making the total 128 deg., 32 min.

SOLUTION:

$$S = \frac{12 + 13.5 + 2}{2} = 13.75$$

$S - a = 0.25$
$S - b = 1.75$
$S - c = 11.75$

$$\text{Tan.}\ \frac{B}{2} = \frac{I}{S - B}\sqrt{\left(\frac{(S-a)\,(S-b)\,(S-c)}{S}\right)}$$

From which

$$\text{Tan.}\ \frac{B}{2} = 0.3493$$

Angle B = 38 deg., 30 min.

Other angles (for proof) 135 — 30
6 — 00
38 — 30
180 — 00

where
S = sum of the sides divided by two.

Lawrence, Mass. C. J. WILDER.

Feed Pump Capacities

MANY TIMES it is handy to know how to estimate the approximate capacity of a direct acting boiler feed pump, without referring to a pump catalog. In such cases, the following method will give satisfactory results.

For simplex pumps, take the square of the diameter of the water piston and multiply it by twice the stroke to get the boiler horsepower which the pump will safely take care of. In the case of a duplex pump, take four times the stroke.

As an example, a 5 by 12 simplex is rated by Worthington at 565 b.hp. From the rule $5^2 \times 12 \times 2 = 600$ which is near enough.

Again, take the 4 by 6 duplex, rated at 460 b.hp. $4^2 \times 6 \times 4 = 384$ which is somewhat low, but in small pumps, especially duplex, 20 per cent may be safely added to the result. For 4-in. stroke, the correction should be 50 per cent and for 3-in. stroke 100 per cent.

An application of the above rule, combined with a reasonable amount of judgment should enable any one to engage in an offhand discussion of feed pump capacities without discredit to himself.

It is also well to remember when discussing boiler feed pumps that at sea level, neither head nor suction is required to handle water at 160 deg. F. At lower temperatures, a suction of about 2 ft. for each 10 deg. F. below is safe. For high temperatures a head of about 2 ft. for each 10 deg. F. above, is about right although a trifle low. At 210 deg. F. or 50 deg. F. above 160 deg. F. there should be a head of at least 12 ft. on the pump suction.

Bloomfield, N. J. JAMES O. G. GIBBONS.

FOR WIND pressure on chimneys, Robins Fleming, concluding a discussion of experiments and formulas in Engineering of London states that 20 lb. per sq. ft. of projected area (diameter times height) may be taken as safe for ordinary heights and conditions. For unusual heights and locations subject to very high winds, 25 lb. per sq. ft. should be used. Point of application of the total wind pressure in determining the overturning effect would be taken as half the height of the chimney and this overturning moment should be balanced by the gravity moment, i.e., weight of the chimney times half its diameter, for a brick chimney, by the gravity plus safe tensile resistance for a reinforced concrete chimney and by the safe resisting moment of the guys for a steel stack.

Parallel Operation of Alternators

REGARDING THE ARTICLE "Parallel Operation of Alternators" by V. E. Johnson, on page 326 of the July issue of Power Plant Engineering, in the fourth paragraph he states that the only load shifting possible is that brought about by a change in the relative steam consumption. The field strength has no effect on the speed of the synchronous machines and therefore none of the governors, nor on the division of the kilowatt output. This is nearly correct for machines having like characteristics and connected to a non-inductive load, but the majority of alternators carry a highly inductive load, for which the above statement does not hold true. Although generally speaking, the load is changed by varying the speed governors, and incidentally the steam supplied to the prime movers.

When two similar alternators in parallel are supplying an inductive load, they should operate at the same share of the reactive kilowatt-ampere load which is power factor in order that each may take its proper unusually high in machines having low armature reaction. This equalizing of the power factor is done by changing the field excitation, which in turn causes a shifting of the load, depending on the difference in reactive currents between the two machines, and sensitivity of their individual governors, design, characteristics, etc. The load may be shifted several hundred kw. in this manner.

Waynesboro, Va. J. M. MYERS.

A. Referring to Mr. Myers' comment on my article, this problem may be better understood if all phenomena except those that pertain to load division are disregarded, and the analysis based upon fundamentals only.

It is evident that a definite relation exists between power input and power output, and that the latter can not be increased, in a turbine unit for example, without a corresponding increase in the steam consumption. With two such units in parallel on a bus it follows axiomatically that kilowatts can not be transferred from one to the other without some change in the steam flow.

Building, then, upon this fundamental principle, the next step is to determine if this change in steam flow can be brought about by field manipulation. In order for such a change to take place it would obviously be necessary for the governor to respond to a variation in field strength.

The automatic governing mechanism is controlled by the rotational speed of the unit in such a manner as to increase the steam flow when the unit slows down. Aside from mechanical imperfections, nothing else can automatically affect the input. Therefore, unless a manipulation of the generator fields cause a change in the relative speeds of the two units under consideration, it can not affect the automatic governing mechanism and consequently can have no effect on the steam input, nor on the kilowatt output.

Being in synchronism, the two units can not change their relative speeds. It is therefore obvious that the division of load as determined at the outset by the manual adjustment of the governor remains unchanged regardless of what is done to the fields. That is to say: inasmuch as the field manipulation in no wise affects the speed relations existing between the two units, it can not affect the governor mechanism, and so can have no effect on the steam input nor on the kilowatt output.

There are some seeming exceptions to this rule which should be noted here in order to keep the record straight. Increasing the field on either machine will increase the bus voltage, unless a compensatory adjustment be made on the other unit. If the bus voltage is changed, the total output of the two units will also change, and this variation in load taken care of by a re-positioning of the governors. Under the new condition the relative division of kilowatt output may not be the same as it originally was, due to differences in governing. It is ordinarily assumed that the bus voltage is kept constant, so that this phase of the problem is of little significance.

Another exception is due to the fact that even with constant bus voltage and kilowatt output, the input requirements can be changed to some degree by a change in the losses in the generators. That is to say, if the fields are adjusted so as to circulate considerable wattless current between the units, then the total copper loss will increase above that which would exist if there were no circulating current.

This additional loss would cause both units to slow down, and through the re-positioning of the governors increase the steam flow. Under the new load condition the governor positions relative to each other might be different than they originally were due to dissimilarities in generator design or governor sensitiveness. The same circulating current would likely in non-identical units produce different copper losses. While this phase of the discussion is of little practical value it indicates that strictly analyzed the input can be influenced by field adjustment.

In a manner analogous to that in the preceding paragraphs, the total losses can be increased by shifting the wattless current taken by the external circuits from one unit to the other, if the design is different as regards copper loss. In other words, one of the units might have a lower stator winding resistance than the other so that the wattless current flowing through it would produce less $I^2 R$ loss. The total steam consumption could in that manner be varied an amount equal to the difference between the copper losses under the two operating conditions. Both units would change their speed a trifle, and there might be some difference in the relative governor positions under the two conditions.

It must, however, be borne in mind that the shifting of load under the conditions set forth in these examples is not due to the transfer of wattless current from one unit to the other in any sense except that this change may with dissimilar units produce different losses. They represent moreover a rather hair splitting analysis of what may happen when the field strengths are changed.

Throughout this discussion, as in the original article, it has been assumed that the two generators are in parallel on an electrically "stiff" bus. If the units are tied together through long "loose" lines the con-

ditions are entirely different because considerable voltage difference can exist at the machine terminals. In such cases increasing the field will tend to raise the voltage in the network adjacent to the generator and so directly affect the load.

V. E. JOHNSON.

First Use of Pulverized Coal

WHEN AND WHERE was pulverized coal first used?

J. H. M.

A. There seem to be no records of the earliest experiments in the use of pulverized fuel but in 1831 John Samuel Dawes, an ironmaster of Bromford in Stafford, England, was granted Patent No. 6207 for feeding fuel through a conical tube and blast pipe into a puddling furnace. In 1857 John Bourne took out a patent and in 1861 he published the first book to advocate the use of powdered fuel in iron furnaces. In 1867 T. R. Crampton, another Englishman, conducted a long series of experiments in the use of pulverized coal in both puddling furnaces and steam boilers. From these experiments he formulated several principles and pointed out the difficulties which would have to be solved before such fuel could be used successfully.

In 1867-68 B. F. Isherwood, Chief Engineer of the U. S. Navy, made tests for the U. S. Government of pulverized coal burning apparatus patented by Messrs. J. D. Whelpley and J. J. Storer of Boston, Mass., but found that, considering the cost of the apparatus, grate burning was less costly.

From 1868 until 1895 there were numerous experiments but real progress was negligible. In 1895, however, pulverized coal firing was successfully applied by Messrs. Hurry and Seaman to rotary cement kilns at the plant of the Atlas Portland Cement Works after which its use spread rapidly in the cement companies of the U. S.

Following 1895 many patents were taken out in America and Europe under such names as Friedeberg, Ruhl, Pinther, Ruehe, Unger, Rowe & Bender, Bartlett & Snow, Westlake, Wegener, Schwartzkopf, and Cyclone.

The Wegener furnace was developed in Berlin in 1895 and a number of installations made in Germany.

The Schwartzkopf Dust Fuel Furnace, also a German invention, was tried out in England in 1904 but was not adopted. It used a rotary brush.

The first pulverized coal boiler to meet with any degree of success in England was the Bettington boiler. Claude Bettington made his preliminary experiments in South Africa, then came to the United States where he took out his first patents. The final experiments and completion of the boiler were done in England. A number of Bettington boilers were installed in the British Empire from 1905 to 1913.

After the successful cement kiln adaptation in 1895 development in the United States was intermittent. Records show that an annealing furnace in Erie, Pa., was fired by pulverized coal in 1896, but there was no widespread use in the metallurgical industry until the results of certain experiments made by the American Steel & Iron Manufacturing Company of Lebanon, Pa., were published in 1912.

In 1910 J. E. Blake of the Blake Pulverizer Co. installed a pulverizer and blower in connection with a 300 hp. boiler at the power plant of Henry Phipps in Pittsburgh and in 1913 another Blake installation was made at the Peter Doelger Brewery in New York City. But the history of pulverized coal firing under steam boilers in the United States really began with the installation at the workshop of the Missouri, Kansas & Texas Railroad in Parsons, Kansas, in 1916. In this plant eight Heine water tube boilers were so fired. That installation was closely followed in the same year by an installation at the American Locomotive Works in Schenectady, N. Y.

In 1918 the Milwaukee Electric Railway & Light Co., began exhaustive research and experiments with pulverized coal in their Oneida Street heating plant at Milwaukee. Through these experiments the principles and technique of pulverized coal firing were so far perfected that they were given to the engineers of the world in a paper by John Anderson, chief engineer of the company. The conclusions were that the use of pulverized coal is economically advantageous in plants with a continuous day and night load of 2400 kw. or more. In 1920 the first unit of the huge Lakeside Plant of the Milwaukee Electric Railway & Light Co. was placed in operation using pulverized coal. This was the first large commercial plant where pulverized coal was planned and successfully used and its use from the time of that installation grew by leaps and bounds.

Pre-Heating High-Viscosity Fuel Oil

IN A GREAT many places, coal has been replaced for both heating and steam generation by oil and oil-burning equipment. Experience in the burning of oil soon establishes the fact that heavy, viscous oils which have high resistance to flow contain more heat per gallon than do the lighter oils. In addition to this, the low-gravity oils are actually cheaper by the gallon as well, so that the cost advantages of using them piles up considerably. An oil which is highly viscous and resistant to flow, however, is also highly resistant to proper atomization, unless the viscosity of the oil may somehow be reduced. It is of course possible to thin such oils by pre-heating them before they reach the burner nozzle.

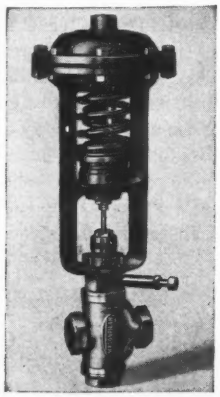
There are of course different ways in which oil can be pre-heated, but the efficiency with which it is pre-heated will inevitably affect the cost sheet. If it is heated at some distance in advance of the oil burner, it is evident that some of the heat will be given up, or wasted, before it reaches the burner, and just so much of the heat will have been wasted. A method of heating which seems to be very efficient, and which is finding considerable favor, is that of using some sort of electrical heating unit directly within or upon the oil supply lines, and since these can be placed quite close to the burner, very little heat loss is entailed. Heating a low-gravity oil up to 300 or 350 deg. F. will make all the difference in the world in it, and will often permit the burning of oils that could not otherwise be handled at all in a given piece of equipment, with considerable saving in the fuel bill.

Peoria, Ill. JOHN E. HYLER.

New Equipment

Mason-Neilan Ball Bearing Regulator

MASON-NEILAN REGULATOR CO. of Boston has developed a new pressure reducing regulator known as the No. 505 Series and equipped with non-corrosive stainless steel ball bearings which roll up and down with the valve stem travel and reduce friction to a minimum.



Ball bearings also turn freely under the spring adjusting screw and permit pressure settings to be easily accomplished.

Flexible, multiple springs permit the use of larger diaphragms and are said to increase the sensitivity and accuracy of the regulation. A self-alining spring button prevents spring tilt and side sway from interfering with smooth operation. These regulators are equipped with the Centroguide Valve, an advanced type of valve in which the valve plug is centrally guided at the top and bottom of the valve body. It is claimed that this practically eliminates wire drawing and cutting of the valve plug and valve seat rings.

Fafnir Ball Bearing Pillow Block

NEW Fafnir cork-insulated ball bearing pillow block of the wide inner ring type with self-locking collar has a deep groove, large-ball design for high load capacity, thrust as well as radial, and housing of Fafnir design, being of cast iron with ribbed base, to possess maximum strength with limited physical dimensions. It is prelubricated at time of assembly, the lubrication being renewable by means of grease tubes, as the proper fitting is included in the housing. Insulation is a cork pad, treated so that no separation of particles can occur, which fits into the housing and around the bearing to insure silent operation. It acts as a seal against the escape of lubricant or the entrance of dirt. Design and construction give compactness, low friction, self-alinement, easy assembly and silence.

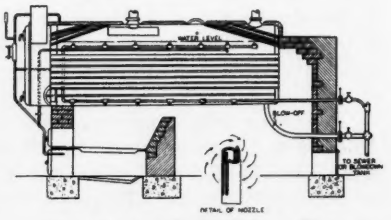
New Circuit Breaker Interrupts 20,000 Amperes

WESTINGHOUSE ANNOUNCES a new low voltage "De-ion" breaker, similar in general to the standard 600 amp. 600 v. AB breaker brought out several years ago, with the major exception that the new breaker has an interrupting capacity of 20,000 amp. The new AB-20 is totally enclosed, being mounted in the standard 600 amp. molded case. It is available in all ratings from 50 to 600 amp., complete with standard tripping accessories and motor mechanism.

To secure a heavy duty AB-20 breaker it was necessary to double the interrupting capacity of the standard AB breaker. This was accomplished by a complete redesign of the contact structure and major modifications in the "De-ion" chambers and operating mechanism. The cold cathode principle of arc extinction, which has been successfully used in the standard duty breakers, has been retained.

Mechanical Boiler Cleaner

THE NATIONAL BOILER IMPROVEMENT CO., Washington, D. C., was recently organized to manufacture and distribute the Mechanical Boiler Cleaner. Two of the incorporators are Claude W. Owen, President of the Washington Board of Trade, also President of the E. G. Schafer Co., and W. C. Hanson, former President of the National Pipe and Supplies Assn.



The Mechanical Boiler Cleaner, which has proven highly satisfactory in many plants, is a device for removing scale forming material from boiler water by a combination of surface and bottom blowoff piping fitted with special nozzles properly spaced to reach the sections of the boiler where scum or sludge is likely to form.

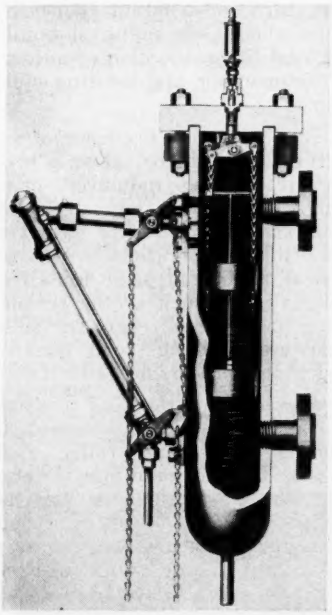
Surface scum is removed through a positive system of agitation and suction caused by a series of scum cups extending across the boiler or steam drum below the water level. These cups create a circular swirling motion as suction takes place when the blowoff valve is opened. In a similar manner, larger cups or mud nozzles are spaced along the bottom of the boiler or mud drum which draw the sludge and dislodged scale with the regular operation of the blowoff system.

By the design and arrangement of the nozzles a positive agitation or forced circulation covering all parts of the boiler surface takes place thus drawing off scale forming particles in suspension and causing such scale as is not firmly attached to drop off. These loosened particles which are too large to pass through the blowoff discharge may be removed when the boiler is washed.

Requiring no change in boiler construction, the Mechanical Boiler Cleaner is easily installed, firmly fastened in the proper place inside the boiler with positive connection to the regular blowoff outlet.

Yarway Water Column Improved

YARNALL WARING CO., Chestnut Hill, Philadelphia, announces several important improvements in the Yarway Floatless Hi-Lo alarm water column and Sesure inclined water gage. The following standard Yarway features have been retained: the use of balanced solid



weights, working on displacement principle, to operate the whistle alarm at high and low water levels; attachment of gage valves directly to water column, with chains set well back from gage glass, to allow clear vision of inclined water level in glass and to prevent strain on the glass by chain pull; gage glass inclined from vertical to permit reading water levels from below.

Improvements include a smaller, lighter water column body; a simpler, more flexible and more responsive operating mechanism for the Hi-Lo alarm; inclined connecting member at top of gage, which drains back the condensate that might otherwise collect at this point and cause erosion and corrosion of the glass.

Yarway water columns and gages are built for working pressures up to 1500 lb. For pressures up to 250 lb., the water column is made of cast iron; for higher pressures, the column is wrought steel. Tubular gage glasses are used for pressures up to 400 lb.; for higher pressures, flat glass inserts are furnished. A special feature of the Yarway heavy duty flat glass insert is an offset condensate groove which carries condensate down alongside the glass, thereby eliminating the corrosive and erosive action of this moisture.

Oil Circuit Recloser

AN OIL CIRCUIT RECLOSER, a single-pole outdoor automatic device for application to suburban branch and rural distribution circuits, has been announced by the General Electric Company. Designated as the type FP-19, it is for circuits from 2200 v. up to 7500 v. and 50 amp. continuous loads. There are only two connections to the distribution circuit—no control power is necessary.

The new device opens promptly on a short circuit and then closes automatically after a few seconds, remaining closed if the fault is removed and resetting itself for the next emergency. If the fault is not cleared, however, the device will

open again immediately and reclose after a few seconds. It will do this three times, so that, if the fault is of temporary nature, service will be restored automatically and the recloser will be automatically reset, requiring no attention by the operating department of the power company.

If the short is of permanent character and is sustained after three reclosures, the device will lock itself open and indicate its position by a target that is easily seen. The recloser can be manually operated by pushing the target into the position desired (open or closed).

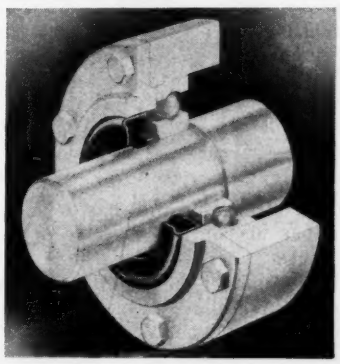
The recloser is in a weatherproof case arranged for pole mounting, and weighs 70 lb. It is installed by slinging it under a cross arm, clamping it on, and cutting it into the line.

Major applications of the new recloser include installation on long branches connected to major feeders, branches where tree conditions are bad, and main feeders on the low side of step-down substations of low kv-a. rating.

Garlock Oil Seal

GARLOCK KLOZURE, a new oil seal developed by the Garlock Packing Co., Palmyra, N. Y., has just been placed on the market. It consists of four parts, the adapter, spreader, sealing member and case.

In assembling, the sealing member slips into the case and the spreader, a flexible metal, V-shaped ring with serrated edges fits into the modified or so-called chevron shape of the sealing member. The angle of the V in the spreader is broader than the angle of the seal-



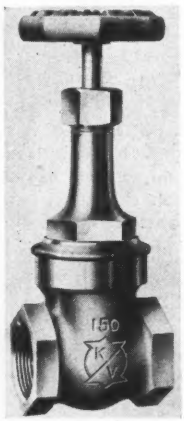
ing ring so that when the spreader is brought into contact with the sealing ring it causes the ring to grip the shaft lightly in a leakproof contact.

What is termed the adapter is a metal ring, flanged to contact the spreader and exert a constant pressure upon it. It also bears against the body of the packing ring, holding it in place and preventing leakage between the outside diameter of the packing ring and the case.

Material of which the Klozure sealing ring is made is claimed to be resistant to the action of oil and high temperatures and to possess a low coefficient of friction. They are made in a wide range of standard sizes from 3/8 to 3 in. diameter and a number of different diameters and depths.

Kennedy's New Gate Valves

THE KENNEDY VALVE MANUFACTURING CO., Elmira, N. Y., announces a new line of rising stem heavy standard bronze gate valves for 150 lb. working steam pressure and 250 lb. working water, oil or gas pressure. The operating mechanism of this valve, known as Fig. 45, employs solid wedge discs which are simple, heavily proportioned and accurately machined, and with no small quick-wearing parts which might cause trouble in service. A flexible connection is provided between the disc and the stem so that the stem will not bind or spring when the valve is closed. The stem is made of a bronze composition with high tensile and tor-



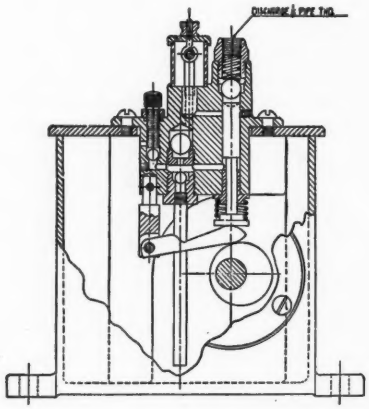
sional strength, and has a large number of contact threads in the bonnet.

The bonnet hexagon has been made extra-large and close to the body so that when a wrench is applied for installing or disconnecting, there will be no danger of distorting the bonnet. Additional features of this new Kennedy design are the deep stuffing box with gland and square section molded packing rings, the large non-heating malleable-iron hand wheel which is secured to the stem by a nut, and the heavy, wide pipe-end hexagons with generous number of threads.

New Designs of Hills-McCanna Lubricator

HILLS-MCCANNA CO. of Chicago announces a new force-feed lubricator known as Model ET, consisting of types SF (sight feed) and BF (blind feed). The two types are essentially the same except for the built-in sight feed on type SF. Type BF is intended for use where there is a possibility of sight feed breakage due to rough handling or where the installation is in such a position as to render it invisible to the operator. Glycerine or blinker sight feeds are available for use with type BF lubricator.

Operation is simple as can easily be ascertained by a short study of the accompanying diagram of type SF. Due to the clutch drive construction, practically any number of stops can be made on the circumference of the drive shaft. The



rocker arm drives the plunger in a straight line, eliminating wear due to side thrust. On the discharge stroke the oil is forced to the delivery point under pressure, (adjustment from one to ten drops at each stroke against varying pressures up to 2000 lb. is possible) and at the same time oil is drawn from the reservoir for the next delivery. The exact amount of oil passed to the sight feed is delivered at each stroke. There is no pressure or vacuum inside the sight feed glass.

All working parts of the lubricator including the clutch drive and rocker arm operate in a bath of oil, thus reducing wear and noise to the minimum.

Cutting Power Costs

DYNAMIC EXHIBITS will tell the story of cutting power service costs in every department of the Eleventh National Exposition of Power and Mechanical Engineering, December 3 to 8, at Grand Central Palace, New York. Not merely will they tell the story of products and machines, but by actual operation they will show the new achievements which research and development have wrought during the quiet years.

Transmission in all of its phases will be a subdivision of mechanical industry in which important savings can be effected. Comprehensive and advanced presentation of new ideas in major fields of mechanical engineering such as prime movers, transmission, and fuel economy, will be supplemented by a variety of industrial specialties. For insulation materials, against the background of a giant thermometer, engineers attending the exposition will be able to determine, for any temperature, precisely what type of insulation is recommended and the thickness in which it should be applied. For the heating and ventilating industry there will be exhibits of low temperature insulation, and, in contrast to this, will be types designed for service at 1950 deg. F. A new forging heater, using an electric eye or photo-cell for controlling temperature, is an item which visitors will find ultra-modern. Said to be the only forging heater ever built that will control temperature during the process of heating, this electric eye prevents under or over-heating of the metals being forged. Presented in the same section, an electric rivet heater will appeal to those responsible for construction generally, boiler shops, car shops, shipbuilding, and the production of automotive, conveying, and hoisting equipment.

By the largest producer of salt in the world will be shown a process for making industrial brine, wholly automatic and dissolving rock salt and filtering saturated brine in one operation, to produce a clear, saturated brine for all industrial uses, such as the regenerating of water softeners for boiler feedwater, dyeing, food packing, and many processing industries.

Power generation and transmission problems will be reviewed, including silent and roller chain drives, flexible couplings, friction clutches, free wheeling clutches, variable speed control equipment, all keyed to the economic factor, as the slogan of this exhibit is Speed Control is Cost Control.

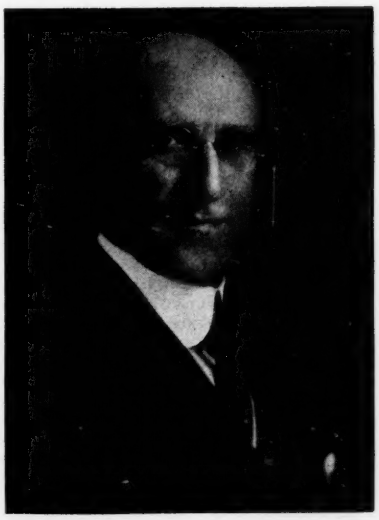
Concerned with transmission problems in the factory will be displayed shaft hangers, blocks, couplings, gears, sprockets, speed reducers, motor reducers, and valve controls. Pillow blocks, designed to operate with roller or ball bearings, will supplement a complete range of completely enclosed and sealed bearings. Transmission by means of belting will include belting, belt lacer pins, belt hooks, and belt surface preservatives, one exhibitor coupling the subject of leather belting with an exhibit of the economies to be effected by industrial lubricants.

The story of instruments, it has been said, is "never old and never told." For every advance in technology, instruments must provide the data for the advance. Subsequently they must record the new operation. Designed to improve fuel economy, a large variety of recording and indicating precision instruments will be shown. Entirely new and based on a new principle, an electrically operated flow meter will be demonstrated for the first time publicly at this year's exposition. Significant changes also have taken place in the further development of carbon dioxide and draft recorders, indicating pointer draft gages, and industrial gas analysis test sets. Recording instruments will be shown to measure steam developed at the source, and also the amounts used by various departments in a manufacturing plant.

Indications point to a great display of original exhibits designed to tell a condensed story in terms of actual operating economy. Charles F. Roth, who has managed the Expostion of Power and Mechanical Engineering in previous years, is again personally in charge, with headquarters in Grand Central Palace.

Calvin W. Rice

Calvin W. Rice, secretary of the American Society of Mechanical Engineers since 1906, died suddenly on Oct. 3. Mr. Rice was born at Winchester, Mass., in 1868 and was graduated from Massachusetts Institute of Technology in 1890 with the B.S. degree in electrical engineering. He then held successively positions as engineer of the Thomson-Houston Co.; engineer with the General Electric Co.; engineer with the Silver Lake Mines in Colorado; consulting engineer for the Anaconda Copper Mining Co.; electrical engineer of the Kings County Electric Light & Power Co., and later with the New York Edison Co. and the Consolidated Subway Co.; vice-president of the Nernst Lamp Co.; and consulting engineer with the General Electric Co.



It was from this varied experience in electrical, hydraulic and steam engineering, combined with managerial and executive work, that Mr. Rice was called to the secretaryship of the A.S.M.E. in 1906. Almost immediately after joining the A.S.M.E. in 1900 he took an active interest in the society and played a cosiderable part in gaining the assistance of Mr. Carnegie and the other engineering societies in the raising of funds for the Engineering Societies Building.

His ability to gain the coöperation and assistance of others was largely responsible for the growth and concerted effort of the engineering societies in this country and the coöperation of foreign engineering societies in fundamental standardization work.

Asa P. Hyde

Born in Pitcher, N. Y., in 1861, Mr. Hyde carried on his father's business of chair manufacturing for several years in Norwich and later in Oxford, N. Y., but, in 1904 he turned to the power plant field, becoming chief engineer of the plant of Security Mutual Bldg., in Binghamton, N. Y., while it was yet under construction. In this plant he utilized many of his own ideas, developing it to a point of efficiency and economy where it was outstanding among the private plants in the southern section of New York State. His work was so effective that he was often called in consultation by business firms and by other engineers when important problems were to be solved, and was ever ready to give his assistance freely.

Remaining in charge of the Security Building until 1932, when he retired on account of ill health, he had many men under him who were taught his sound principles of plant management and operation and who are now holding responsible positions in other plants. On his retirement, his son, Jesse F. Hyde, was appointed as chief engineer of the Security plant and to carry on further the family tradition, another son, Ernest E. Hyde, is now chief engineer of the Broome County Home.

Mr. Hyde has always been active in his advocacy of the individual plant, where it shows superior economy and was able always to show that his plant was "good business" for its owners.

He died on Sept. 3, 1934, leaving five sons and a daughter. His work has been outstanding as a chief engineer who knew his job and did it well. His friendship has been loyal and unswerving to those whom he knew and trusted and who will remember him as a valued adviser and one of Nature's noblemen.

Franklin M. Bowman

Franklin M. Bowman, Vice-President of the Blaw-Knox Co. with whom he had been associated since 1912, died at his home in Pittsburgh, Pa., at the age of 65.

Mr. Bowman received his early education at the School of Practical Science, Toronto. He graduated in 1890 and in 1893 was awarded the degree of Civil Engineering by Toronto University.

With the Riter-Conley Mfg. Co. from 1892 until 1912, he held the positions of Chief Draftsman, Chief Engineer, Director and Secretary successively. In 1912 he resigned to join the Blaw-Knox Co.

As Vice-President of the Blaw-Knox Co., Mr. Bowman was in charge of the Transmission Tower and Structural Steel Divisions of that company. Mr. Bowman was a member of the American Society of Civil Engineers, the American Iron & Steel Institute and other associations.

Daniel Bradford Badger

Daniel B. Badger, chairman of the board of E. B. Badger & Sons Co. of Boston, died Oct 3 at his home in Winchester, Mass., at the age of eighty-four.

Mr. Badger had been associated with the company, which was then Hicks & Badger, a firm of coppersmiths, since 1864, starting in as an apprentice, and advancing through the various offices of vice-president, president and finally in 1933 to chairman of the board.

In spite of his advanced years, Mr. Badger was active in business and civic affairs and was constantly engaged in philanthropic enterprises.

News From the Field

LIBRARIANS whose work deals with petroleum and allied subjects have formed a Petroleum Section within the Science-Technology group of the Special Libraries Assn., in order to make a decimal classification of petroleum subjects and facilitate inter-library loans. Further information may be had from Albert Althoff, Librarian, General Petroleum Corp. of California, 2525 E. 37th St., Los Angeles, Calif.

ENGINEERS ANNOUNCE that the new Broadway low-level vehicular tunnel between Alameda and Contra Costa Counties in California will require 16 fans for ventilating purposes, capable of supplying 70 tons of air per minute. These fans will be built by B. F. Sturtevant Co., Hyde Park, Boston, Mass. When completed, California's new vehicular tunnel will be the largest subterranean vehicular tunnel in the world. It will be of the two parallel bores type. Each bore will be 3168 ft. long and will have a 22-ft. roadway and a 3-ft. sidewalk.

THE PLIBRICO JOINTLESS FIREBRICK Co., Chicago, Ill., announces the appointment of Harry H. Hustedt as distributor at New Orleans, La. Mr. Hustedt's address will be 400 N. Peters St. and he will carry a stock of Plibrico refractory products at New Orleans. He will also provide complete installation service.

GEARS & FORGINGS, INC., with general offices at Cleveland, Ohio, which has been in receivership since April 1, 1932, has effected a reorganization under the name of Ohio Forge and Machine Corp. This new company will operate the former Ohio Forge and Van Dorn Dutton divisions of Gears & Forgings, Inc., located on adjoining properties at Cleveland, Ohio. The officials who will direct the new company are F. H. Chapin, President of The National Acme Co., as chairman of the board; S. C. Dalbey and J. M. Clem, who formerly operated the Ohio Forge Co. before the merger of Gears & Forgings, as President and Vice-president, respectively; H. B. Newell, formerly of the Fawcus Machine Co. of Pittsburgh and later Vice-president in charge of operations of Gears & Forgings, Inc., as Executive Vice-president; T. E. Leighton of the original Van Dorn & Dutton Co. as Secretary and Treasurer; R. B. Tripp former Sales Manager of the Ohio Forge Co. and later General Sales Manager of Gears & Forgings, Inc., as General Sales Manager. The standard line of speed reducers formerly marketed under the G & F trademark will continue to be manufactured in the Cleveland plants as heretofore.

SKINNER ENGINE Co., Erie, Penn., announces the appointment of George F. Wolf as Manager of its Chicago Office, 20 North Wacker Drive, succeeding the late W. T. Greenleaf, whose death occurred early this year. Mr. Wolf has, for the past several years, been Manager of the Company's Cleveland Office.

D. W. BURGOON, Vice President and General Manager was elected also to membership on the Board of Directors at the stockholders' meeting of Yeomans Brothers Co., Chicago. H. T. Jeffrey was elected Secretary in addition to his office of Sales Manager.

FOSTER ENGINEERING Co., Newark, N. J., has joined the Exhibitors Advisory Council, New York City, with S. G. Farrington as its representative. Sarco Co., New York, N. Y., has also joined, Clement Wells, representative.

WITH A VIEW to providing better coverage and more complete service in the south, Combustion Engineering Co., Inc., New York City, has divided this territory into two districts. The Southeastern district will extend from Richmond to Florida, with headquarters at Charlotte, N. C., which is more central to the territory served than was Atlanta. This district will be in charge of T. C. Heyward as District Manager. Associated with Mr. Heyward are C. A. Weston and Arthur B. LeClere. The Southwestern district will extend south of the Kentucky-Tennessee border and west of Atlanta to the Mississippi River. It will be under the Chattanooga District Office with L. C. Haller as District Manager. B. W. Webb now District Engineer at Cincinnati will shortly join the Sale Organization at Chattanooga. E. L. Shuff, formerly in charge of the Atlanta office, has been made District Manager in Cincinnati.

EDGE MOOR IRON Co., Edge Moor, Del., announces that Wm. E. S. Dyer was selected president of the company and assumed responsibilities on September 25. Mr. Dyer established an enviable reputation in the consulting engineering field in which he has been most actively engaged for nearly 30 yr. in the design, construction and operation of numerous high-efficiency power plants developed through a wide experience combined with extensive research throughout Europe and America.

ANNOUNCEMENT was made in the October issue that Rapp & Hollis, Inc., of Chicago, was made representative of Chain Belt Co. It is learned that this firm will represent the company only in the foundry equipment business.

SPENCER VAUGHAN, electrical engineer, formerly with the Westinghouse Electric and Mfg. Co., has recently become associated with the Spencer Thermostat Co. of Attleboro, Mass., where he has charge of all operations including the development of new products.

F. S. KINGSTON and B. L. Conley, both well known in the electrical industry, have organized as the Kingston-Conley Electric Co. to manufacture high-grade fractional horse-power heavy-duty motors. The company was established early this year. The factory is located at 66 York Street, Jersey City, New Jersey and its newly designed motors are now in production.

UNDER THE DIRECTION of H. S. Colby, General Sales Manager, a Western Division of the sales organization of Combustion Engineering Co. has been formed, comprising the Chicago, Detroit, Indianapolis, St. Louis, Kansas City, Houston, Tulsa, Minneapolis and Denver offices. Roger W. Andrews, until lately Assistant to the President of the Blaw-Knox Co. will be in charge of this division as Western Manager.

Mr. Andrews' connection with the steam power field dates back to 1910 when he joined the Northern Equipment Co., later becoming sales engineer, service engineer, chief engineer, secretary and general sales manager of that company. In 1914 he formed the R. W. Andrews Co. of Chicago, handling power plant equipment, and a year later joined with Grant D. Bradshaw, then steam engineer of the Cambria Steel Co., to form the Andrews-Bradshaw with headquarters in Pittsburgh.

GEORGE B. PAGE, Manager of the Philadelphia office of the Terry Steam Turbine Co. died on Sept. 10, 1934. Mr. Page had been connected with this organization as Philadelphia district manager since January 1, 1932. He was a graduate of Cornell University, class of 1908; and was previously employed by the B. F. Sturtevant Co. in New York City, and the Rust Engineering Co. in Pittsburgh. Mr. Page is survived by his wife and two children.

AT MT. HOLYOKE COLLEGE, South Hadley Mass., the installation of a battery of 120 General Electric oil furnaces in an unusual new central heating plant is nearing completion. The furnaces in this battery are arranged in 24 groups of five units each. The number of groups in operation at any time is automatically determined by steam demand, which is itself automatically controlled by outside dry-bulb temperature. In addition to this, in order to take care of requirements not affected by outside temperature—such as interval heating of classrooms—the operator at the central plant has close and accurate control over the admission of steam to any of the 24 college buildings heated from the central system. No matter what the total steam demand may be, only enough furnaces are "on" to take care of that demand, and they are working at full efficiency and therefore full economy.

ANNOUNCEMENT is made of the consolidation of interests of the Carbondale Machine Co. of Carbondale, Pa., with those of the Worthington Pump & Mach. Corp., in the general refrigeration field, operating in future as the Carbondale Machine Corp. The Carbondale Machine Corp. will transfer all necessary personnel and equipment to Harrison, N. J., and in the future will build its lines of machinery at the Worthington plants.

SHEPARD NILES CRANE & HOIST CORP. has now concentrated all its manufacturing divisions at Montour Falls, N. Y. The Niles plant in Philadelphia has been closed and its equipment moved to Montour Falls. A new erecting shop especially designed for the manufacture of Niles heavy cranes has been built. The plant formerly occupied by Cronk & Carrier Manufacturing Co. at Montour Falls and which adjoins the Shepard plant, has beeen purchased and affords additional space required by the move of the Niles Division. All of the engineering data, fixtures and tools formerly used by the General Electric Co. in building the Shepard Motor have been purchased from them and Shepard motors and Niles motors are now being produced at Montour Falls, N. Y. The Chemung Foundry in Elmira, N. Y., owned by the Shepard Niles Co. and which produces all its iron castings, is now the only division not located in Montour Falls.

For the Engineer's Library

FLEXITALLIC GASKET CO., Camden, N. J., is distributing a catalog entitled Flexitallic Gaskets for Pipe Flanges, All Boiler Openings, which shows in large size illustrations the construction of the various gaskets made by the company and in addition to specifications and prices, gives tables of dimensions and full descriptions of these gaskets.

ENGINE-DRIVEN type SA 300 welding generator unit for 40 v., 300 amp., made by Lincoln Electric Co. and driven by a Buda 6-cylinder engine of 44 hp. at 1800 r.p.m. is described in bulletin No. 304 issued by Lincoln Electric Co., Cleveland, Ohio.

THE LOUIS ALLIS CO., Milwaukee, has just issued an 8-page bulletin describing the advantages and economies of shaftless motors for driving modern production machinery.

It describes and illustrates the various types of shaftless motors, their construction and electrical characteristics and contains tables and other engineering data of interest to every manufacturer and user of motorized production machinery.

FROM SMOOT ENGINEERING CORP., division of Republic Flow Meters Co., of Chicago, Ill. comes a new 24-p. catalog, S-10 describing the principles, construction and application of Smoot Regulators. Clear illustrations, tables of capacities and ranges of control are given for piston and diaphragm types both pilot-valve and air-operated.

ROOTS-CONNORSVILLE BLOWER CORP., Connersville, Ind., has just issued Bulletin 50-B11-devoted to the new high duty Connersville vacuum pumps. Many improvements are claimed by the manufacturer, including accessible roller bearings, improved lubrication, gears and bearings fully protected, herringbone gears, and elimination of stuffing box attention.

VERTICAL FOUR CYCLE gas engines ranging from 180 to 360 horsepower are described in a six page folder, S-550-B6, recently issued by the Worthington Pump & Machinery Corp., Harrison, N. J.

INSTALLATION of demountable skating rink equipment in swimming pools is described in a four page bulletin by the Carbondale Machine Co. of Carbondale, Pa.

WORTHINGTON Service at A Century of Progress and other World's Fairs is the title of an interesting illustrated booklet just issued by Worthington Pump and Machinery Corp. It describes the use of Worthington products at various World's Fairs. Another bulletin recently issued by the same company is devoted to Worthington Automatic Power Pump Receiver Sets. This bulletin is known as W-423-B2.

FROM THE Littlefuse Laboratories in Chicago comes catalog No. 6 describing their products, fuses for high voltage, for instrument protection, for radio and auto and neon tattelites, which protect against excessive voltage and indicate the trouble. These last are used to protect instruments, transformers, condensers and rectifiers against voltage surges; to draw off static charges from machinery; to test for blown fuses, defective resistors and condensers; to indicate resonance peaks and for stroboscopic effects.

HENRY VOGT MACHINE CO., Louisville, Ky., is distributing a new series of boiler bulletins covering the company's design of three drum and four drum, curved tube type boilers. These bulletins illustrate the recent and representative installations that are serving a diversity of industries and institutions.

THE BORDEN CO., Warren, Ohio, has just issued a new bulletin covering a full line of modernized Beaver pipe tools, among those in which engineers will be particularly interested being the No. 6-R Beaverette Ratchet used for threading pipes ranging from ¼ to ¾ in., and the No. 38-R Beaver Ratchet designed for threading standard pipes from 2½ to 3 in. in diameter.

NORTON CO., Worcester, Mass., has just issued an attractive folder in which they print the story of Bortz (Diamond) in grinding wheels.

HILLS-MCCANNA CO. of Chicago has just issued a catalog describing its new Model ET force-feed lubricators.

ILG ELECTRIC VENTILATING CO., Chicago, has just issued its booklet C50, a condensed catalog and handbook of ventilating and air-conditioning equipment.

THE LAWRENCE PUMP & ENGINE CO., of Lawrence, Mass., manufacturers of Lawrence Vortex Centrifugal Pumps, has just had printed for distribution a new bulletin covering their line of stage pumps. The centrifugal pumps described in this new four-page folder are multi-stage pumps in 2, 4, and 6 stages, for heads up to 1200 ft. The pumps are all of the horizontally split casing type, and are suitable for electric, motor, belt, steam turbine, or internal combustion engine drive.

INGERSOLL-RAND CO., New York City, has just published a pamphlet entitled The Story of the Boulder Dam, Volume 4, which should prove of extreme interest to engineers interested particularly in excavation and construction work of a nature which is aided by the use of pneumatic tools.

CENTRIFUGAL PUMPS of the two-stage volute type in sizes from two to eight inches are described in a four page bulletin, W-318-B5, issued by the Worthington Pump & Machinery Corp., Harrison, N. J.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., required by the Act of Congress of March 3, 1933, of Power Plant Engineering, published monthly at Chicago, Illinois, for October 1, 1934.

State of Illinois, } ss.
County of Cook, }

Before me, a Notary Public in and for the State and county aforesaid, personally appeared Arthur L. Rice, who, having been duly sworn according to law, deposes and says that he is the Editor of the Power Plant Engineering and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher, Technical Publishing Co., Chicago, Ill.
Editor, Arthur L. Rice, Chicago, Ill.
Managing Editor, R. E. Turner, Chicago, Ill.
Business Manager, E. R. Shaw, Chicago, Ill.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.)

Technical Publishing Co.
E. R. Shaw, Chicago, Ill.
Arthur L. Rice, Chicago, Ill.
K. L. Rice, Chicago, Ill.
Madge W. Rice, Wilmette, Ill.
Chas. S. Clarke, Chicago, Ill.
R. E. Turner, Chicago, Ill.
A. W. Kramer, Chicago, Ill.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)

There are none.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the twelve months preceding the date shown above is ..... (This information is required from daily publications only.)

TECHNICAL PUBLISHING CO.
ARTHUR L. RICE,
Editor.

Sworn to and subscribed before me this 26th day of September, 1934.
[Seal.] EDDIE H. KAHL,
Notary Public.

(My commission expires March 20, 1936.)

Power Plant Construction News

Ala., Mobile — Kraftliner Gumming Corporation, Mobile, recently organized subsidiary of Southern Kraft Corporation, Mobile, plans installation of electric power equipment in new local plant for manufacture of gummed paper kraft products. Cost close to $100,000. Arnold Jacoby is general manager of Kraftliner company.

Colo., La Salle—Common Council is arranging special election to approve bond issue of $42,000, fund to be used for new municipal electric light and power plant. Proposed to ask bids for Diesel engines and other equipment at early date.

D. C., Washington — National Park Service has secured appropriation of $47,700 for purchase of three gas-driven pumping units and accessories and for new central water supply system in Yellowstone National Park. Proposed to ask equipment bids at early date.

Ill., Chicago — Dearborn Paper Co., 860 Rees Street, plans installation of motors and other power equipment in new one and two-story plant for paper manufacture, storage and distribution, at Twenty-first and Loomis Streets, 130x460 ft. Cost about $80,000. J. M. La-Point is company engineer.

Ill., Waukegan—Board of Directors, Alexian Brothers Hospital, Waukegan, care of Maher & McGrew, 1564 Sherman Avenue, Evanston, Ill., architects, has plans under way for new multi-story electric power plant at institution. Cost over $400,000 with electric generators, boilers and other equipment.

Kan, Kingman—City Commission plans extensions and improvements in municipal electric light and power plant, including new Diesel engine unit and accessories. Cost about $30,000. Proposed to ask bids in near future.

Ky., Athertonville — Cummins Distillery Corporation, Louisville, Ky., care of Walter C. Wagner, Breslin Building, Louisville, architect, plans installation of electric power equipment in connection with expansion and improvements in distilling plant at Athertonville. Cost about $200,000, including machinery.

Ky., Fisherville—Blue Grass Distilling Co., Louisville, Ky., care of W. L. McComas, Louisville, head, recently organized, plans installation of electric power equipment in new distillery at Fisherville, where property has been acquired. One-story boiler plant is proposed. Cost over $100,000, with machinery.

Md, Baltimore—United States Industrial Alcohol Co., Curtis Bay, has approved plans for new power house at local plant, reported to cost over $75,000, with equipment, and soon begins superstructure. Work will be carried out in connection with general plant improvements, now under way. Main offices are at 60 East Forty-second Street, New York, N. Y.

Mich., Benton Harbor—George B. Bright, 2615 Twelfth Street, Detroit, Mich., refrigerating engineer, has plans under way for new multi-story cold storage and precooling plant at Benton Harbor, for company now being formed by George H. Kittredge, Detroit, and associates. Cost about $80,000, with equipment.

Mich., Benton Harbor—Berrien Brewing Co., recently formed with capital of $150,000, plans installation of power equipment in new local brewery. Company has acquired former local plant of Spencer Barnes Furniture Co., and will remodel and equip for plant. Cost about $80,000, with equipment. George P. Racine is president.

Mich., Detroit—Bohn Aluminum & Brass Corporation, 2512 East Grand Boulevard, plans installation of electric power equipment in new aluminum experimental plant. Cost about $60,000. Company is forming a new subsidiary and in near future plans new multi-unit plant for sheet and wire aluminum products, operating under special process, majority of machinery to be electric-operated. Cost over $3,000,000, with equipment. Company engineering department will be in charge.

Mich., Menominee—City Council is securing a Federal loan and grant for $803,000, fund to be used for new municipal electric light and power plant. Plans will soon be completed. T. R. Hasley is city engineer.

Mich., Port Huron—Lakeside Brewing Co., recently formed with capital of $275,000, plans installation of power equipment in new local brewing plant. Company has acquired former local brewery of Port Huron Brewing Co., Bard and Michigan Streets, and will remodel, improve and equip. Cost close to $90,000. Edward Cole, 2937 Leslie Street, Detroit, Mich., heads new company.

Minn., St. Paul—Seeger Refrigerator Co., 850 Arcade Street, plans installation of electric power equipment in new additions to refrigerator manufacturing plant. A building permit has been issued. Cost close to $75,000. C. H. Johnston, 360 Robert Street, is architect.

Mo., Kansas City—Eagle Bottling Works, 1903 Cherry Street, Harry Rubenstein, president, plans installation of power equipment in new multi-story brewing plant at Nineteenth and Cherry Streets. Cost about $225,000. A. B. Anderson, Davidson Building, is architect; George Wentzel, Davidson Building, is consulting engineer.

Mo., La Plata—City Council has plans nearing completion and soon takes bids for new municipal electric light and power plant, using Diesel engine generating units. Also for new electrical distribution system. Fund of $100,000 has been arranged. E. T. Archer & Co., New England Building, Kansas City, Mo., are consulting engineers.

Nev, Reno—Amador Mother Lode Mining Co., Reno, care of O. E. Chaney, Reno, president, recently organized, plans installation of electric power equipment, hoists, conveyors and other mechanical equipment for development and operation of gold-mining properties. A stock issue of $200,000 is being arranged, considerable portion of fund to be used for purpose noted.

N. Y., Binghamton—Nineteeen Hundred Corporation, manufacturer of washing machines, parts, etc., plans installation of electric power equipment in new additions to local plant and at branch factory, St. Joseph, Mich. Entire project will cost about $100,000.

N. Y., Webster—Rochester Gas & Electric Co., Rochester, N. Y., is considering extensions in power transmission system at Webster and vinicity. Cost close to $50,000. Company engineering department is in charge.

N. D., Devils Lake—City Council is arranging financing to total $300,000, through Federal aid, for new municipal electric light and power plant. Plans have been drawn by Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., consulting engineer.

N. D., Dickinson—Lehigh Briquetting Co., manufacturer of fuel briquettes, plans installation of power equipment in new plant units, for large increased capacity. Fund of $400,000 is being arranged for project. W. F. Burnett, 322 Fifth Street North, Fargo, N. D., is company representative in charge. K. A. Loven is general manager.

Ohio, Cincinnati—Kroger Grocery & Baking Co., 35 East Seventh Street, has plans under way for new power house for service at plant on State Street. Cost over $100,000, with equipment. Fosdick & Hilmer, Union Trust Building, Cincinnati, are consulting engineers.

Ohio, East Palestine—City Council is considering installation of new equipment in municipal electric light and power plant, estimated to cost about $30,000. Herbert Lemley, Safety-Service Director, is in charge.

Ohio, St. Bernard—Cincinnati Chemical Co., Cleaneay Avenue, Norwood, Cincinnati, Ohio, has plans nearing completion for new one-story power house at plant at St. Bernard. Cost over $35,000. William E. Bodenstein, Second National Bank Building, Cincinnati, is consulting engineer.

Tenn., Memphis—Slumber Products Corporation, 38 South Dudley Street, plans installation of motors and other power equipment in connection with rebuilding of mattress and bedding factory, recently destroyed by fire. Loss close to $125,000.

Texas, Goose Creek—City Commission is arranging bond issue of $300,000, fund to be used for new municipal electric light and power plant. Proposed to begin work soon.

Utah, Bountiful—City Council has authorized a bond issue of $156,000, proceeds to be used for new municipal electric light and power plant, using Diesel engine-generator units and auxiliary equipment. Also for purchase of present electrical distribution system of Bountiful Light & Power Co., and extensions and improvements in same.

Va., Fredericksburg — General Textile Mills, Inc., is planning installation of electric power equipment, including motors, controls, etc., in connection with proposed rebuilding of local silk mill, recently destroyed by fire, with loss estimated over $100,000. Headquarters are at 450 Seventh Avenue, N. Y.

Wis., Milwaukee — Miller Brewing Co., 4002 West State Street, has plans for new one-story steam power plant at brewery, 55x85 ft., and will begin construction at early date. Cost about $40,000, with equipment.